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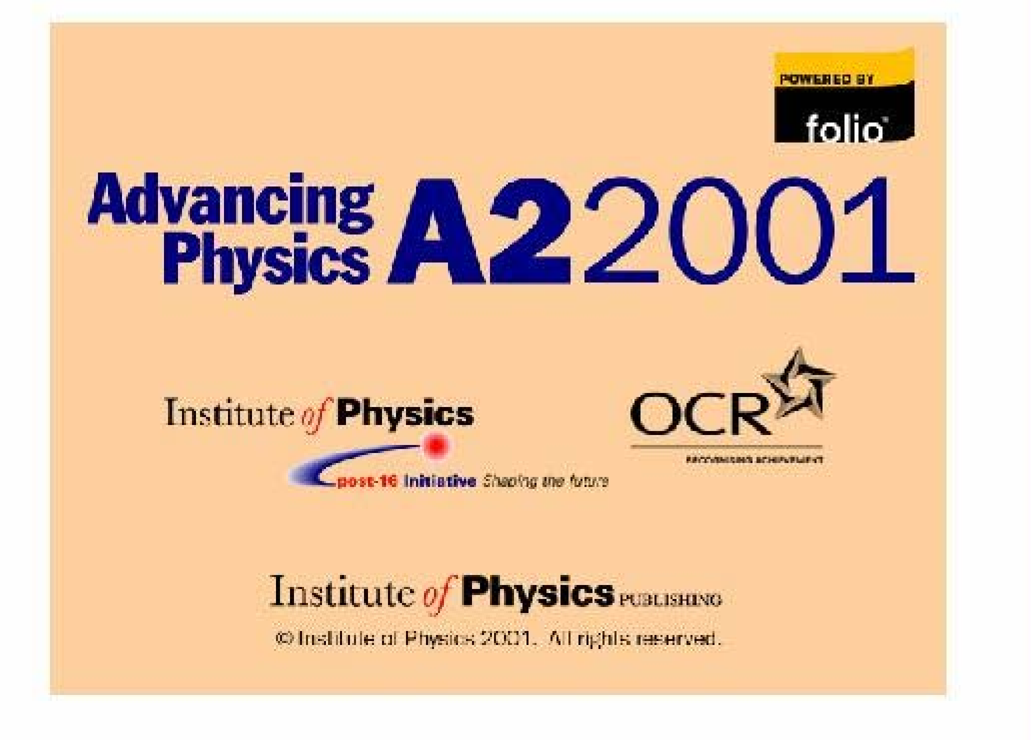

Advancing Physics A2 2001

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STUDENT GUIDE

SCHEMES OF WORK

These schemes of work show how the A2 course activities fit together. Chapters 10-14 form the Unit "Rise and Fall of the Clockwork Universe" . Chapters 15-18 form the Unit "Field and Particle Pictures". There is also a section called "Case Studies -Advances in Physics" which contains various articles which are designed to give you practice for the Synoptic Paper at the end of the course. This paper will call upon your understanding and knowledge of the whole course – AS and A2.

EXAMPLE:

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills covered**	**Text book refer-ences**
		type	content				
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	

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 and to complete the 'Try these' questions! Ask for help if you cannot complete these !!
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 10 – Creating Models

Specification Section 5.4.1.1 Creating Models

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

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills covered**	**Text book refer-ences**
		type	content				
5-1	10.1 What if ….?	a. b c	Models as simplified description of reality, obeying definite rules, Exponential changes: rate proportional to quantity, decay curves, dN/dt=-kN Radioactive decay: activity, background, randomness, decay constant, half-life,	A10S –WorldMaker models of forest fire, percolation, rabbits A20S – look at one, modify and/or construct another Model bacteria population (by hand and/or Excel) Q10C Disposal of radioactive waste Expt – decay of protoactinium(NB follow local rules) Simulation using dice (A50E), WorldMaker (A40S, 60S) and/or Excel models Q20S Randomness and half-life	Q20S Randomness and Half Life Q30S Decay in theory and practice Qs from SG p.8 Perhaps Q40S 'Model growth and sample decay'	N3.1,2,3	Ch 17 Pg 380-383

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills covered**	**Text book refer- ences**
		type	content				
7-1	10.2 Stocks And Flows	a. b c	Capacitance, $C=Q/V$, farad, Decay through resistor, time constant RC, half-life, $dQ/dt=-Q/RC$, $Q/Q_o=e^{-t/RC}$ Radioactivity by analogy: $N/N_o=e^{-\lambda t}$, $t_{1/2}=\ln 2/\lambda$ Other egs of exponential change, $dQ/dt=kQ$ in general, growth and decay, testing for exponential: constant ratio, log graphs Energy stored in capacitor $E={}^1/_2QV$, area under Q,V graph,	Demo A90D 'Super-capacitor', Expt – investigate capacitor behaviour (A100E, 120D or w/s) Demo – overloaded capacitor, NB safety screen, eye protection Q50S 'Short Qs on charging capacitors' (good warm-up on Q, I) Expt and/or datalogging demo (A130E)– measure capacitor discharge; D30O 'Analogies between charge and water' Model discharge –Modellus A140S, A150S, A180S and/or Excel; extension for mathematically able A160S 'Approximations to e' Q90S 'Radioactive decay with exponentials', D40O 'Half-life and time constant' Demo – capacitor lighting bulbs and running motor Q120S 'Energy to and from capacitors'	Q60S 'Charging capacitors' Q70S 'Discharge and time constants' Perhaps A170S 'Exponentials and powers' SG p.19 Could use Q80S Q110S 'Energy stored in capacitors'		CH. 10 Pg218-223 Ch 17 Pg 380-383

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills covered	Text book refer-ences
		type	content				
8	10.3 Clockwork Models	a b c	Introduction to oscillator vocab: amplitude, period, harmonic, isochronous; $f=1/T$ Investigation skills: controlling variables, reducing and estimating errors, getting a straight line graph SHM, $x=A\sin(2\pi ft+\phi)$, restoring force proportional to displacement, $d^2s/dt^2=a=-(2\pi f)^2x$, $(2\pi f)^2x=k/m$ for mass on spring, v -t and a-t graphs, phase relationships	Build a time-measuring device, given string, springs, masses, bottles etc Expt circus or do-and-present A200P, 210P, 220P. 230P Perhaps D60O ‘A language to describe oscillations’ Practical investigation of factors affecting period of pendulum Demo A240P ‘Looking at an oscillator – carefully’, D70O ‘Snapshots of the motion of a simple harmonic oscillator’ Modelling oscillations: A250S, 270S, D100O ‘Graphs of SHM’, perhaps D80O, 90O, 110O Test predictions from models by experiment A260E ‘Loaded spring oscillator’ Perhaps A300S ‘Making links with mathematics’ (phase relationships)	Q150S ‘Revisiting motion graphs’ Perhaps A290S ‘Slopes and Models’ Q160S ‘Oscillators’ Q170S ‘Energy and pendulums’ Extension for more able Q190S ‘Harmonic oscillators’	N 3.1, 3.2, 3.3	CH 6 Pg 142 – 1150

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills covered	Text book refer-ences
		type	content				
2	10.4 Resonating	a. b. c.	Energy stored in stretched spring Energy of oscillator = PE+KE = $^{1}/_{2}mv^{2}$ + $^{1}/_{2}kx^{2}$, energy at x=0, max Resonance, natural frequency, width of response curve increases as damping increases	Model A370S ‘Energy in oscillators’, D130O ‘Energy flow in an oscillator’ Perhaps Q220S ‘Bungee jumping’ Demos or do-and-present A320E, A330E, A340E, A350E D140O ‘Resonance’ Perhaps A360S ‘Modelling resonance’, Q240S ‘Oscillator energy and resonance	Q210D ‘Energy in a simple oscillator Optional (for mathematically inclined) Q230X ‘Energy in a oscillator: with calculus’ SG Qs p.28 Q250S ‘Resonance in car suspension systems’ Reading 30T ‘The Tacoma Narrows bridge collapse’ and optional 40T ‘Tacoma Narrows: re-evaluating the evidence’		Ch 6 Pg 151 – 2

Chapter11 – Out into space

Specification Section 5.4.1.2 Out into space

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
(

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills covered**	**Text book refer-ences**
		type	content				
3-1	11.1 Rythms of the heavens.	a b c	·to make an object move in a circular path, a force must act perpendicular to its velocity ·a centripetal acceleration can be found by a = v2 / r and the force required to cause it must be F =mv2 / r or F = mw2r ·no work is done when a force on a body acts perpendicular to its motion	Activity 10S 'Watching the planets go round' Activity 20S 'Retrograde motion' File 30T Spreadsheet Data Table 'Planetary orbit data' Question 10D Data handling 'Using Kepler's third law' Activity 30D Demonstration 'Galileo's frictionless experiment' Activity 40D Demonstration 'Testing F = mv2 / r ' Activity 60S 'Driving round in a circle' File 40L Launchable File 'Modelling circular acceleration'	Read at least one of … Reading10T'Brahe and Hamlet' Reading20T 'Hubble' Reading 30T'The problem of longitude' Activity 50H Home Experiment 'Going around in the kitchen' Q. 20W'Orbital velocities and acceleration' Q 30S 'Centripetal force' Q 40S 'Circular motion – more challenging' Q 50C 'Centrifuges' Q 70W 'Radians and angular speed'		Ch 3 Pg 62 – 66 Ch 25 Pg 594 – 599.

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills covered	Text book refer-ences
		type	content				
4	11.2 Newton’s Gravitational Law.	a b c	Learning outcomes · $F = -\frac{Gm_1m_2}{r^2}$ ·the concept of gravitational field, and diagrams to represent it ·gravitational field strength · $g = -\frac{GM}{r^2}$ and its graphical representation · how to calculate the orbit radius and time of a satellite or planet	Activity 70S "Variations in gravitational force' Activity 80S 'Gravitational universes' Activity 90S 'Gravitation with three bodies' Inverse square law- butter gun. Geostationary satellites - Activity 110S 'Probing a gravitational field' File 80T Spreadsheet Data Table 'Acceleration data for Apollo'	Q 60C 'How Cavendish didn’t determine G and Boys did' Q 80W 'Newton’s gravitational law' Q 110S 'Finding the mass of a planet with a satellite' Q 90C 'Are there planets around other stars?' Q 120D 'The gravitational field between the Earth and the Moon'		Ch 2 Pg 41 – 46

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills covered	Text book references
		type	content				
2	11.3 Arrivals and departures	a b c	·momentum = mass x velocity ·force is a rate of change of momentum ·the thrust of a jet is the momentum carried away per second by the jet ·the law of conservation of momentum: the vector sum of momentum is unchanged in an interaction between objects ·in consequence, interaction forces come in equal and opposite pairs	Activity 120E Experiment 'Low friction collisions and explosions' Activity 130E Experiment 'Newton’s cradle' Activity 140D Demonstration 'Kicking a football' Law of momentum – derive equation Activity 160S 'Modelling collisions' File 90M Movies 'Collisions from different points of view' Activity 170D Demonstration 'Testing a rocket engine' Activity 180S 'Crunch – gently!'	Q 140W'Change in momentum as a vector' Q 150S 'Impulse and momentum in collisions' Q 160S 'Collisions of spheres' Q 170C 'Collision with spaceship Earth' Reading 90T ‘Sling-shotting’ spacecraft or ‘gravity assist’ Q 180S 'Jets and rockets' Q 190C 'Getting a satellite up to speed'		Ch 2 Pg 32 – 33 Ch 3 Pg 68 – 70

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills covered	Text book references
		type	content				
6	11.4 Mapping gravity	a. b c	· gravitational potential energy difference in a uniform field = mg?h ·gravitational potential is gravitational potential energy per unit mass ·gravitational field strength = − gravitational potential gradient ·gravitational potential around a point mass ·the total energy of a body orbiting in a gravitational field is gravitational potential energy plus kinetic energy	Exploring uniform gravitational fields. Activity 190D 'Exploring potential with a tennis ball' Activity 200D 'Loop-the-loop' Gravitational potential in a radial field : Activity 210 'Gravitational slides' Activity 220S 'Storing energy with gravity' Activity 230S 'Inferring fields' Activity 250S 'Variations in field and potential' AND Activity 260S 'Probing gravitational potential' OR Activity 270D Demonstration 'Measurements with gravitational slides' AND Activity 280S Software Based 'Relating field and potential' Total energy and escape **(optional)**	Q 200W 'Pole vaulting' Q 210S 'Gravitational potential energy and gravitational potential' Activity 240S'Analysing data from the Apollo 11 mission to the Moon' Q 220D 'Gravitational potential difference, field strength and potential' Activity 290S 'Setting up energetic orbits' Q 230D 'Changing orbits' Q 240D 'Why is a 'black hole' black?' Q 250S 'Summary questions for chapter 11'	C3.3, N3.1, N3.3, IT3.2, IT3.3	Ch 3 Pg 57 – 62 And 66/7

Chapter 12 – Our Place in the Universe

Specification Section 5.4.1.3 Our place in the Universe.

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

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hrs / week)	Key skills	Text book refer-ences
		type	content			Covered	
4-2	12.1 Observing the Universe.	a b c	·astronomical distances in the Solar System can be measured by radar ·distances to nearby stars can be found by parallax ·some larger distances are estimated by the apparent brightness of ‘standard candles’, e.g. Cepheid variables and Type 1a supernovae ·the cosmological distance scale is still subject to uncertainty ·velocities of astronomical objects can be established by the Doppler shift with $\frac{d\lambda}{\lambda} = \frac{v}{c}$ for v much less than c. ·masses of astronomical objects can be found from the velocities of objects orbiting them at known distances or in a known time. ·spectra of distant objects over a wide range of wavelengths provide knowledge of their chemical composition	Activity 10E 'What do you know about cosmology?' Could also show powerpoint presentations; Hubble etc. OR/AND Use ‘Red Shift’ AND ‘SkyMap Pro’ For quick guided tours of the universe. OR/AND use the following Display Materials : 20S, 40S, 50S, 60S, 70S, 80S and 100S Measuring astronomical distances : Activity 20E 'Range finding and parallax' Activity 40E Experiment 'Brightness and distance' Activity 50E Experiment 'Summer Sun remembered' File 10S Spreadsheet Data table 'Magnitude and brightness' Radar ranging and Doppler shift : Activity 70E 'Investigating the measurement of distance using an ultrasonic sensor' Activity 80 'Tap-tap range finding' Activity 110P Presentation 'Changes in velocity and rotation' (using rotating loudspeaker) Activity 120D Demonstration 'Doppler shift using microwaves' Activity 90S 'The space police' Activity 100S 'The relativistic Doppler effect'	Activity 30E 'A homemade reflection spectroscope' Activity 60H 'Two-million year old light: Seeing the Andromeda nebula' File 20I Image 'Looking for longer, seeing further' Reading 20T 'The ladder of astronomical distances' Q 10X 'Logarithmic scales' Q 20S 'Measuring distances within the solar system and beyond' Q 30C 'Apparent star brightnesses and logarithmic scales' Q 40S 'Comparing intensities for lamps' Q 50S 'Trip times tell distances' Q 55S 'Doppler shifts in astronomy' Q 60S 'Binary stars' Q 70S 'Using orbital data to calculate masses'		Ch 25 Pg 600 – 628. Ch 26 Pg 639-642

6-1	12.2 Was there a ‘Big Bang’ ?	a b	·Red shifts of distant galaxies give evidence of the expansion of the Universe. A red shift $z = \frac{d\lambda}{\lambda}$ corresponds to an expansion in scale of $\frac{R_2}{R_1} = 1 + z$ ·Current estimates of the expansion time-scale of the Universe put it at about 14 ± 2 Gy. ·Evidence that the Universe has evolved from an initial uniform, hot dense state comes from the existence of the cosmic microwave background. ·There are still fundamental problems in explaining the major features of the Universe.	Looking at evidence for the expanding universe – Red Shift. Looking at spectra – emission and absorption- Demo of emission – H_2, N_2,Hg Use : http://jersey.uoregon.edu/vlab To show examples of spectra. CLEA – Hubble constant (if time allows – but very good for experience of ‘real’ spectra) Activity 130S 'The cosmological red shift'. Evolution from hot to cool Activity 140P Presentation 'The Universe' – singly or in pairs.	Q 80D 'Astronomical distances' Q 90D 'Calculating the age of the Universe' Readings: 20T 'The astronomical ladder of distance' (important) 50T 'The breakthrough of the year' 60T 'The sky is dark at night: A reason to think the Universe has evolved' 70T 'Life CV: Edwin Powell Hubble' Q 95S 'Redshifts or quasars' Q 100S 'cosmic microwave background radiation' Q 110C 'Evidence for a hot early Universe'	C3.2, C3.3	Ch 26 Pg 642 – 650

Chapter 13 – Matter :very simple

Specification Section 5.4.2.1 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) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	**Text book refer-ences**
		type	content			Covered	
5	13.1 Up,up and away	a b c	· Boyle’s law pV = constant, or $p \propto m / V$ for mass m or $p \propto N / V$ for N molecules · Charles law $V \propto T$ if temperature T is in kelvin · the pressure law $p \propto T$ if temperature T is in kelvin · the idea of an absolute zero of temperature 0 K on the kelvin scale · the mole, the Avogadro constant (N_A), the molar gas constant R and the Boltzmann constant k. · The combined form $pV = nN_AkT = nRT$ for n moles of gas	Density and mass of air : Activity 10E 'The density of air' The gas laws : Activities : 20E 'Changes in volume, changes in pressure' (simple apparatus only available) 30E'Changes in temperature, changes in pressure' (Use Bourdon gauge !OR use liquid N_2 when available) 40E 'Changes in temperature, changes in volume' 50S 'Exploring the rules for pressure' 60S 'Exploring the rules for volume' Also use Software ‘Stark – Molecular Dynamics’ Go to > gas behaviour And select ‘pressure-volume’ ‘pressure –temperature’ and ‘pressure-number of atoms ‘	Q 10S 'Floating or sinking?' Q 20E 'Gases and mass' Q 30X Exposition–Explanation 'Pumping up my tyres' Q 40S 'Using the ideal gas relationships'		Ch 7 Pg 185 – 190

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	**Text book refer-ences**
		type	content			Covered	
3-1	13.2 The kinetic model	a b c	·The relationship $pV={}^{1}/_{3}Nm\overline{v}2$ for the kinetic model of a gas, and the meaning of root mean square speed · That the average (translational) kinetic energy of a particle in a gas is equal to ${}^{3}/_{2}kT$ where k is the Boltzmann constant and T is the kelvin temperature · How the kinetic model explains the gas laws summarised by the relationship $pV = NkT$ · That the total internal energy U of an ideal gas is given by $U= {}^{3}/_{2} NkT$ if energy of vibration and rotation can be ignored · How to estimate the root mean square speed of a gas molecule ·About evidence supporting the kinetic model of a gas: *expansion into a vacuum, diffusion, Brownian motion* · That a single molecule in a gas moves in a random walk as a result of the many collisions it makes with other molecules · How the behaviour of real gases deviates from the predictions of the simple kinetic model	Activities 70P 'Brownian motion' 80D 'Collisions produce a force' 90P 'One collision: Many collisions' Building a model for gases : Activities : 110S 'Do the molecules know?' 120S 'Watching atoms cause pressure' 130S 'Heating a gas, changing pressure' 140S 'Compressing a gas, changing pressure' 150S 'Speeds of molecules and how they vary' Activities: 70D 'Brownian motion' 170S 'Diffusion from random motion' 180S 'Differences of concentration' Random walk experiment using hex graph paper. 190S 'Simulated random walk' 200D 'Speed of sound in gases'	Q 50S 'Momentum and collisions with a wall' Q 60S 'Kinetic theory by numerical example' Q 70S 'Kinetic theory algebraically' Q 80S 'More about the kinetic theory of gases' Q 90S 'The speeds of gas molecules: Some questions' Q 100S 'Speed of sound and speed of molecules'	N3.2, N3.3 C3.1b	Ch 7 Pg 190 – 195

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	**Text book refer-ences**
		type	content			Covered	
3	13.3 Energy in matter	a b d	·The internal energy U of a material can be changed by doing work W or by thermal transfer of energy Q, with $\Delta U = W + Q$. This expresses the law of conservation of energy. · That energy ΔE can change the temperature q of a substance in accordance with the relationship $\Delta E = mc\Delta\theta$, where m is the mass of the substance in kilograms, c is the specific thermal capacity of the substance and $\Delta\theta$ is the change in temperature. · That water has a surprisingly high specific thermal capacity, with important environmental and practical consequences.	Activities : 210E Experiment 'A solar panel' (optional) 220E 'Measuring the specific thermal capacity of a metal' 230P 'Warming and cooling by pushing and pulling'	Q 110S 'Specific thermal capacity: Some questions' Q 120C 'The wonderful oddity of water' Q 130S 'Thermal transfers in the home' Q 140D 'Thermal changes'	C3.1a, C3.1b	Ch 14 Pg 314 – 316 Ch 13 Pg 304

Chapter 14 – Matter:very hot and cold

Specification Section 5.4.2.2. Matter:hot or cold

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) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	**Text book refer-ences**
		type	content			Covered	
4	14.1 The ‘magic ratio’ ε/kT		· particles in matter have an average energy of thermal activity of the order kT · values of kT may be expressed in joule per particle, electron volt, or kJ mol^{-1} · bonds are characterised by the energy ε needed to break them. · at high temperatures, bonds break and matter comes apart. Atoms come apart into ions and electrons. The ratio ε /kT is small even for large ε. · at low temperatures, thermal activity is feeble, and ε /kT is large except for processes with very small ε. Matter condenses to solid or liquid, and complex structures form. · many processes start happening at an appreciable rate when ε /kT is in the range 10 or 15 to 30.	Activity 10P Presentation 'Temperatures everywhere' At least one of the following Home Experiments : Activity 20H 'Crème brûlée: Carefully controlled changes' Activity 30H 'Chilled confectionery' Activity 40P 'Hot glows' Activity 50P 'Slow motion syrup' (Activity 80P 'Silicone putty in the freezer') Activity 90D 'Changes at liquid nitrogen temperatures' when available. Activity 100S 'Introducing breakouts' Activity 110E 'Staying bound: Breaking out' could be demonstration. Activity 130S 'Energy per atom in some solids'	Q 20S 'Molecules and change' Q 25S 'Energy per particle' Question 35S 'Values of the energy ε = kT' Q 40S 'Particles spreading out' Q 45X 'Matter 'comes apart' ' Q 50S 'Matter starting to 'come apart' One of the following readings : 10T 'Einstein’s solid' 20T 'Equipartition of energy'		Ch 20 Pg 472/3

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills	Text book refer-ences
		type	content			Covered	
5	14.2 The Boltzmann factor exp(-ε /kT)	a b c	· The ratio of numbers of particles in two states differing by energy ε is the Boltzmann factor exp(–ε /kT) · The origin of the Boltzmann factor is the small probability of repeatedly gaining extra energy at random from a large collection of other particles. · To a first approximation the rate of a reaction with activation energy ε is proportional to exp(–ε /kT), and can increase rapidly with temperature. · Reactions can also involve changes in the number of spatial or orientational arrangements of particles.	All of the following activities are useful : 150E 'A race depending only on chance' 160S 'Energy shared among particles' 170S 'Getting lucky: Climbing an energy ladder by chance' 190S 'Following one particle: exponential behaviour' 200E 'Multi-level energy shuffling' ONE of the following activities– students to report back : 230E 'Energy needed to evaporate a molecule of water' Checking for exponential behaviour: 240E 'Conduction in a semiconductor' 250E 'Creep in polythene' 260E 'Chemical clock reactions' 270E 'Vapour pressure in liquids' 280E 'Flow rates of sticky liquids' 290E 'Thermionic emission' The main point of these activities is to check for exponential dependence, thus justifying the model.	As many of the following as possible: Q60X 'Thinking about the Boltzmann factor' Q 70S 'Distributions of particles' Q 80X 'Exponential distributions' Q 90S 'The Boltzmann factor: fB = exp(–ε / kT)' Q 100S 'Density where jet planes fly' Q 110D 'Resistance and conductance of thermistors' Q 120D 'Vapour pressure of water' Q 130C 'Runny liquids' Q 140C 'Contaminated surfaces' Q 150S 'Electrons from hot metal' Readings : at least one - could provide the starting point for a research and report coursework task. 30T ,40T, 50T, 60T		Ch 20

Chapter 15 – Electromagnetic machines

Specification Section 5.5.1.1 Electromagnetic machines. 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

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hrs/ week)	Key skills	Text book references
		type	content			Covered	
6-1	15.1 An electromagnetic world	a b c	· Be able to draw diagrams of flux for a transformer · Be able to describe and explain the action of a transformer · Use terms such as B-field, magnetic flux, flux linkage and induced emf · Calculate flux using $\Phi = BA = \Lambda NI$ where Λ is the permeance · Use the equation $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ for an ideal transformer · Use the equation $\varepsilon = -N\frac{d\Phi}{dt}$ to calculate the size and direction of the induced emf	Activity 10E 'Commercial machines' -range of real em machines. Activity 20E 'Introducing eddy currents' A first look at Faraday's law . Activity 30E 'Faraday's law' Activity 40E 'Magnetic field shapes seen as flux patterns' Activity 50S 'Flux patterns from arrangements of currents' Use Focus -Fields software Electromagnetic induction Activity 60E 'Factors affecting magnetic flux in a coil' Activity 70E 'Investigating electromagnetic induction' Activity 80E 'Constant rates of change' Activity 90S 'Building up a model of electromagnetic induction' Activity 100E 'Model transformers' Activity 110P 'Building up a transformer' Activity 120S 'Modelling transfomers' Activity 130D Demonstration 'Demountable transformer'	Q 10W 'Magnetism reminders' Q 20W 'Magnetic flux' Q 30S 'Magnetic circuits' Q 40S 'Sketching flux patterns' Q 50S 'Magnet down a tube' Q 60S 'Changes in flux linkage' Q 70S 'Electromagnetism' Q 80S 'Rates of change' Q 90S 'Bugging' Q 100S 'Transformers' Q 110S 'The circuit breaker' Q 120S 'Eddy currents and Lenz's law' Q 130X 'Explaining with induction'	N3.1 IT3.3, N3.3	Ch 10 246 – 252

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hrs/ week)**	**Key skills**	**Text book refer-ences**
		type	content			Covered	
4	15.2 Generators and motors		· Be able to describe the action of an a.c. generator (alternator) · Understand that the change of flux linked is produced by the relative motion of the electric and magnetic circuits · Be able to draw graphs of variations of currents, flux and induced emf · Be able to describe the action of an induction motor · Know that a three-phase system is used for large scale power generation and distribution	Activity 150P 'Ways of changing flux linkage' Activity 160P 'Moving a conductor in a uniform field' Activity 170D 'Rotating magnetic fields' Activity 180S 'Changing flux linkage' Generators : Activity 190E 'Examining real dynamos and generators' Activity 200E 'A three-phase generator' Activity 210S 'Building up an alternator' Induction motor : Activity 220D 'Jumping ring' Activity 20E 'Introducing eddy currents' Activity 230S 'Making flux rotate' Activity 240D 'Shaded pole induction motor' Activity 250D 'Model three-phase induction motor' Activity 260D 'Building up an induction motor'	Q 140X 'A bicycle speedometer' Q 150S 'Flux or flux linkage?' Q 160X 'The geophone' Reading 60T 'People and electromagnetism: The inventors and engineers' Q 170S 'Graphs of changing flux and emf' Q 180S 'Alternating current generators' Q 190S 'Electronic ignition' Q 200X 'The induction motor' Q 220X 'A variable speed linkage'	C3.1a, N3.1	Ch 11 264 – 279

Time/ hours	Student Text	Specification		Activities	Minimum student work (2hrs/ week)	Key skills	Text book references
		type	content			Covered	
5	15.3 A question of power	a b c	· to relate the force on a current-carrying conductor to the shape of the magnetic field around it. · to relate changes of flux linked to the rate of cutting of flux · to calculate the force on a current-carrying conductor using $F = ILB$ · to describe the action of a d.c. motor, including the 'back emf' induced in the motor	Looking at motors ; Activity 270E 'A simple motor' Activity 290E 'Forces on currents' Activity 300E 'Force on a current-carrying wire' Forces in dynamos : Activity 310P 'The effect of loading a generator' Activity 320P 'Torque from a motor' Activity 330P 'Using an electric drill' Activity 340E 'Motors that make our world go round...' Activity 350E 'Towards the linear motor' Activity 360D 'Building up to a linear motor'	Q 230S 'Sketching flux patterns, predicting forces' Q 240S 'Forces and currents' Q 250S 'Thinking about the design of the d.c. motor' Q 260S 'Emf in an airliner' Reading 80T 'A wide variety of motors' Q 270C 'The Birmingham maglev' Q 280X 'ICT driven by precision motors' Read article in Text Book (Dobson et al) On 'Motors that make the world turn'. Ch.12.	N3.1, IT3.2	Ch 10 Pg 252 – 254

Chapter 16 – Charge and Field

Specification Section 5.5.1.2 Charge and Field 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

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	**Text book refer-ences**
		type	content			Covered	
5	16.1 Linear accelerators	a b c	· Electric field strength $E = F/q$ · Electric potential V = electrical potential energy/q · Energy transfer to/from charge when it moves through a p.d. is $W = q\,\Delta V$ · velocity v= V (2qV/m) at non-relativistic velocities ($v << c$) · Electric field strength = - potential gradient $E = -\frac{dV}{dx}$ · The electric field can be represented by field lines and equipotential surfaces. · Evidence for the discreteness of the charge on an electron.	Uniform fields : Activity 10D 'A flame between charged plates' Activity 20D 'Using a foil strip to look at uniform electric fields' Activity 30D 'Exploring potential differences in a uniform field' Activity 50D 'Measuring potential gradient with a twin flame probe' Activity 60E 'Measuring potentials in a uniform field conducting paper' Activity 70S 'Relating field and potential' Millikan expt : Activity 90S 'Using electric fields to measure electric charge'	Q 10W 'The uniform electric field' Q 20M 'The uniform electric field and its effect on charges' Q 60S 'Using uniform electric fields' Also one of the following comprehensions : Q 40C 'Thunder clouds and lightning conductors'. Q 50C 'Electrical breakdown in a vacuum' Q 60S 'Using uniform electric fields' Q 70D 'Millikan's oil drop experiment' Extension : Reading 30T 'The ultimate speed'	C3.1a, N3.1, IT3.1 C3.1b, C3.2, IT3.2	Ch 9 Pg 230 – 237

7-10	16.2 Deflecting charged beams		· parabolic path in uniform electric field · force on a moving charge in a uniform magnetic field, $F = qvB$ ·circular trajectory in a uniform magnetic field, radius $r = p/qB$ · $E = q/4\pi\varepsilon_0 r^2$ and $V = q/4\pi\varepsilon_0 r$ in a central field: use of analogy and symmetry arguments ·Coulomb's law: $F = Q1Q2 /4\pi\varepsilon_0 r^2$	Activities 100D 'Deflection of water drops by an electric field' 110D 'Deflecting electron beams in an electric field' 120D 'Deflecting electron beams in a magnetic field' 130S 'Charged particles between plates' 140S 'Circular motion in a magnetic field' Detecting charges: non-uniform electric fields 180D 'Electrical breakdown.' Uses both van de Graaff generator and a spark detector. 190D 'Measuring potential differences between coaxial conductors with a flame probe' 200D 'Exploring potential differences round a charged sphere' 210P 'The 1/r hill: Slope and force' 220E 'Plotting potentials in non-uniform fields'' 240S 'Mapping inverse square vector fields' 250S 'Summing vector fields' 270S 'Radial force, field and potential'	Q 80W 'Getting F = q v B' Q 90S 'Deflection with electric and magnetic fields' Q 100S 'The cyclotron' Q 110M 'Charged particles in electric and magnetic fields' Q 170D 'The electric dipole' Q 180S 'Non-uniform electric fields' Q 200S 'Using the 1/r 2 and 1/r laws for point charges' Q 190S 'Charged spheres: Force and potential' Q 210D 'Testing Coulomb's law'	N3.1	Ch 9 Pg 238 – 244 Ch 24 Pg 576 – 581

Chapter 17 Probing deep into matter

Specification Section 5.5.2.1 Probing deep into matter.

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

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	**Text book refer-ences**
		type	content			Covered	
6	17.1 Creation and annihilation	b c	· Particles can be created and annihilated in matter–antimatter pairs. · Particles and their antiparticles have opposite charges and lepton or baryon numbers. · Electromagnetic interactions arise from the exchange of photons. · Electrons are fermions, which obey the Pauli exclusion principle. · Leptons are particles like the electron, neutrino and their antiparticles. Baryons are particles like the proton and neutron and their antiparticles. · Total energy, momentum and charge are conserved in interactions, as are lepton and baryon number.	Particles and anti-particles. -evidence from bubble chambers Display Material 10S 'Annihilation and pair production: bubble chamber pictures' Conservation laws-- momentum, energy, mass, charge Students record/note of conserved quantities. Activity 10S 'Bubble chamber photographs' Interactions and particles : Activities 30S 'Interactions in particle physics' 40S 'Time and the Muon' 50S 'Identifying particles using Lancaster Particle Physics software' 60P Presentation 'Quark models' also use Hadron Cards	Q 10S 'Things that don't change' Q 30S 'Creation and annihilation' Q 40M 'Particles and interactions' Q 50C 'Creation from annihilation' Q 60M 'Keeping momentum and energy unchanged' One of the following readings : 50T 'Where did all the antimatter in the Universe go?' 60T 'Symmetry and conservation laws'		Ch 24 Pg 554-576

7	17.2 Scattering and scale	a b c	· scattering experiments reveal the structures of atoms, nuclei and nucleons; the smaller the scale the greater the energy needed · atoms have tiny dense positively charged nuclei, made of protons and neutrons packed together at high density · quarks with fractional electric charges combine in threes to form neutrons, protons and other particles, all called baryons · quarks combine in particle–antiparticle pairs to form mesons. · the strong ‘colour’ force between quarks is carried by gluons, which like photons are bosons. Particles which ‘feel’ this force are called hadrons. · at high energies, scattering experiments create a large number of new kinds of particle	Alpha scattering Activity 80S 'Probes scattered by a target' Activity 90S 'Many probes scattered by a target' Activity 100S 'Where scattered probes go' Also use alpha scattering model Changing probe, smaller scale Activity 110S 'The Livingston curve' Activity 120P 'The funding of particle physics' Activity 130S 'The density of nuclear matter'	Q 70S 'Rutherford scattering: energy and closest approach' Q 80S 'Rutherford scattering: directions of forces' Q 90S 'Electrons 'measure the size of nuclei' Q 100S 'Scattering and scale' Q 110S 'Putting quarks together' Q 120C 'Finding parts of protons'	N3.1 IT3.1, IT3.2	Ch 24 Pg 580 – 586

6	17.3 The music of the atoms	a	· Electrons confined in a region of space can be modelled as standing waves, with wavelengths determined by the size and shape of the confining region · The de Broglie wavelength is given by $\lambda = h/p$ · Discrete atomic energy levels correspond to discrete electron standing waves in an atom. · Electrons can make quantum jumps between allowed energy levels, emitting or absorbing a photon whose energy is given by $E = hf = E_{initial} - E_{final}$. · The energy level spacings in hydrogen are given by $E_n = -13.6 eV/ n^2$ where n is the principal quantum number.	Demonstration – Visible spectra Use : http://jersey.uoregon.edu/vlab Again to show spectra. Also , http://www.colorado.edu/physics/2000 for useful models explaining spectra. Activity 140E 'Standing waves – for electrons?' Activity 150S 'Sizing up a hydrogen atom' Explaining the Periodic Table -Pauli Exclusion principal in action.	Q 140C 'How Niels Bohr began quantum theory' Q 80S 'Spectra and energy levels' Q 160S 'How small could a hydrogen atom be?' Q 170S 'Carrots and guitar strings' Q 180D 'Products of the Big Bang'	N3.1 IT3.1, IT3.2	Ch 16 Pg 364 – 371.
1	17.4 Known and unknown		· Matter is ultimately made from just two different classes of particles: quarks and leptons, both fermions. · These interact by exchanging bosons (e.g. photons in electromagnetic interactions). · Particles are created and annihilated in particle–antiparticle pairs	Known and Unknown			Ch24 Pg 565 – 576.

Chapter 18 : Ionising Radiation and Risk

Specification Section 5.5.2.2 Ionising Radiation and Risk

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

Time/ hours	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	**Text book refer-ences**
		type	content			Covered	
8	18.1 Radiation put to use		· Ionising radiations - wide range of uses, in medicine, technology and everyday life · Ionising radiations mainly interact with matter by ionising atoms. α radiation is strongly ionising; β and γ radiation less so · α particles have a definite range in air. particles β a variable range. γ radiation attenuated exponentially in absorbing material. · The unit of absorbed dose is the gray Gy, the energy in J absorbed per kg of material. The unit of dose equivalent is the sievert Sv, the absorbed dose in gray multiplied by numerical factors to allow for the different effects of different types of radiation and tissue · The concept of risk: risk = probability x consequence	Risking and using : Q 10D Demonstration 'The cost of taking a chance' Reading 10T Text to read 'The radium girls' Use and familiarity- everyday uses of radioactivity. Activity 10E 'Radon in the home' Activity 20H 'Radiation in dust' (*These can be adapted for school use as no alpha sensors or TASTRAK presently available*) Activity 30E 'Radiation all around' Activity 60E 'Ions produced by alpha particles' Activity 80E 'Range of alpha particles with a cloud chamber' Activity 90E 'The range of beta particles in aluminium and lead' Activity 100E 'Absorption in biological materials' Activity 110E 'Range of gamma radiation' The following could be repeated from chapter 10 if necessary : Activity 120E 'Measuring the half-life of protactinium' Activity 130S 'Exploring radioactive decay'	Q 20X 'Telling people about risk' One of : Q 40C 'Radon – healthy or harmful?' Q 50C 'How safe are x-rays?' Q 60C 'The mass x-ray programme' Q 70C 'Some of the dangers of flying too high' At least one of the following comprehensions : 80C, 90C,100C, 110C, 130C, 160C,180C. Q120S 'Summary questions for 18.1'		Ch 17 Pg 405-6

5	18.2 The nuclear valley	a c	Stable light isotopes tend to have equal numbers of protons and neutrons; more massive isotopes have a larger proportion of neutrons to offset the mutual electrical repulsion of the protons · The binding energy of a nucleus is the difference between the rest energy of the nucleus and the total rest energy of its individual nucleons. The rest energies are found from the masses, using $E_{rest} = mc2$ · The binding energy per nucleon forms a valley with a minimum near iron · Alpha emission reduces proton and neutron numbers each by 2. Several chains of such decays are known · Electron (b-) emission changes one neutron into a proton. Positron (b+) emission changes one proton into a neutron · Radioactive decays take a nucleus to a state of lower energy. Gamma emission does so without change in numbers of protons and neutrons	Nuclear valley – looking for patterns and rules for stability. Activity 140S 'Binding energy of nuclei' Activity 150S 'Exploring the nuclear valley' Viz!on plug-in for Excel needed. Display materials – use whiteboard but OHPs available. Short Answer Segré chart .	Q 140D 'Radioactive decay series' Q 170D 'Binding energy and mass defect' Q 190C 'Using gamma rays' Q 200S 'Change in energy: change in mass' Q 210S 'Summary questions for 18.2'	N3.1 N3.2	Ch 17 Pg 385 – 399.

3	18.3 Fission and fusion	a b c	· Fission releases energy by a large nucleus such as U-235 breaking into two parts, each more tightly bound than the larger nucleus, by about 1 MeV per nucleon · A fission chain reaction can occur, in which neutrons from one fission event cause other nuclei to undergo fission · There is a critical mass for fissile material, at which the chain reaction becomes self-sustaining · Slow neutrons are captured more efficiently than fast neutrons. Nuclear reactors use a moderator to slow the neutrons, and a coolant to carry away energy. · In nuclear fusion, low mass nuclei fuse to form more massive nuclei which are more tightly bound, by several MeV per nucleon. · Fusion of hydrogen to helium occurs in the Sun. On Earth, fusion has been achieved but fusion as a source of power remains only a possibility.	Need for energy Activity 40S 'Sources of radiation in the UK – some facts and figures' Activity 160S 'Nuclear fission and critical mass' Fission or Fussion Some of the questions listed could be used in class.	Q 220C 'Life and death of a nuclear reactor' Q 240C 'Power in space' Q 230D 'The disappearing Sun' How long will it last? Q 250S 'Fission and fusion – practice questions' Q 260S 'Fusion in a kettle?' Question 270S Short Answer 'Fission in a nuclear reactor – how the mass changes'	N3.1	Ch 17 Pg 399 – 403.