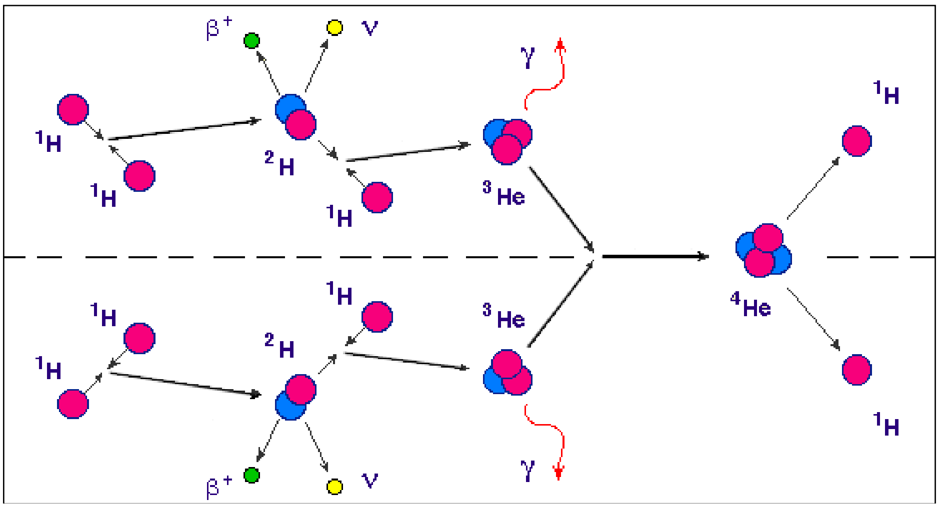
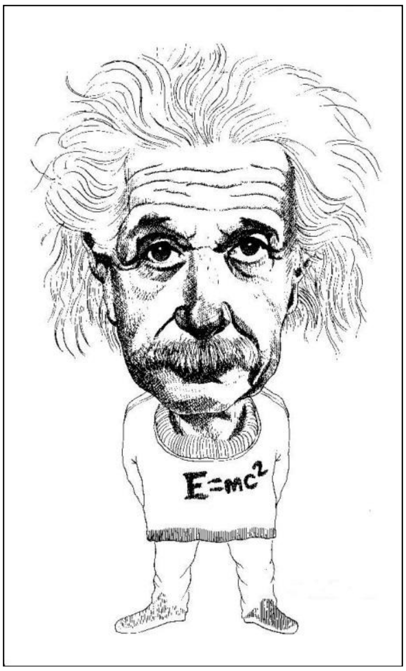
A/S Physics





Probably the best A level in the world

A Level Physics

The A level course is made up of the following units:

- Ph1 Motion, Energy & Matter 20%
- Ph2 Electricity & Light 20%

- Ph3 Oscillations & Nuclei 25%
- Ph4 Fields & Optional topic 25%
- Ph5 Practical Skills Examination 10%

The first two modules make up the A/S qualification.

We are following the **WJEC Physics A' Level Qualification** and the examination board website can be found at: www.wjec.co.uk/qualifications/physics/physics-gce-a-as/

The A level (as GCSE) works on a 'points system' (UMS). Your actual mark in an examination is converted into a number of UMS 'points'. There are 500 UMS marks to collect through the A level course – the more points you collect, the better your grade ☺

Points	see below	>400	399-350	349-300	299-250	249-200	<240
Grade	A*	A	B	C	D	E	U

The A* qualification is only offered on the full A level course. To achieve this, candidates must achieve above 400 UMS with at least 270 UMS from the Ph3-Ph5 examinations.

Each module will contribute to the course as follows:

Module	UMS points	Exam slot	Type of examination
Ph1	100	June Yr12	Exam paper 1½ hr
Ph2	100	June Yr12	Exam paper 1½ hr
Ph3	125	June Yr13	Exam paper 2¼ hr
Ph4	125	June Yr13	Exam paper 2 hr
Ph5	125	March Yr13	Practical Task & Analysis

The A/S modules (Ph1 & Ph2) may be re-sat, at a cost, alongside the A2 examinations at the end of Yr13. However this builds up work, puts candidates under increased stress and often can lead to a decrease in performance.
A student who attains a particularly low grade in A/S is recommended not to follow this subject to the full A level.

Each class is taught by two Physics teachers and will have nine hour-lessons per fortnight. It is important to attend all lessons. The pace of work at this standard is much greater than at GCSE. If lessons are unavoidably missed it is essential to catch up before the next relevant lesson.

You will be expected to engage in sufficient self-directed study. This is usually 4-5 hrs per week in order to ensure that you remain on top of the quantity of new information and 'up-to-speed' with the conceptual development.

Throughout the course it is important to monitor your progress and achievement. There are many ways in which this will happen. One such system is regular topic tests. Track your performance in these tests on this sheet. It is vital that you make the effort to deal with any underperformance. Don't let things pass you by; they quickly build up into a large problem. Ensure you get the feedback from each test that you need to improve.

My target grade is __________

My GCSE point score predicted grade is __________

Test		Score	Grade	Notes/Comments
Ph1	Basic Physics			
Ph1	Kinematics			
Ph1	Dynamics			
Ph1	Energy Concepts			
Ph1	Solids Under Stress			
Ph1	Radiation & Stars			
Ph1	Particles			
Ph2	Electrical Conduction			
Ph2	Electrical Resistance			
Ph2	D.C. Circuits			
Ph2	Nature of Waves			
Ph2	Wave Properties			
Ph2	Refraction			
Ph2	Photons			
Ph2	LASERs			

Mock examinations:

Paper	Mark	Grade
Ph1		
Ph2		

Universal Constants

To study Physics in the wider context, i.e. the whole universe from the largest galactic structures to the smallest sub-atomic particles, we believe that the laws of Physics are constant and true everywhere. Thus we have some numbers that we believe are fixed by our universe (or creator) and are the same everywhere. These are the universal, or fundamental, constants and you will meet them as you progress in the course. **You will not be expected to know these off by heart – they will be in the data & formulae booklet in the exam**. [That said, you've not been doing much in Year 12 if you can't reel off the most common of them at a moment's notice!]

Values and Conversions

Avogadro constant	N_A	$= 6{\cdot}02 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	e	$= 1{\cdot}60 \times 10^{-19}$ C
Mass of an electron	m_e	$= 9{\cdot}11 \times 10^{-31}$ kg
Molar gas constant	R	$= 8{\cdot}31$ J mol^{-1} K^{-1}
Acceleration due to gravity at sea level	g	$= 9{\cdot}81$ m s^{-2}
Gravitational field strength at sea level	g	$= 9{\cdot}81$ N kg^{-1}
Universal constant of gravitation	G	$= 6{\cdot}67 \times 10^{-11}$ N m^{2} kg^{-2}
Planck constant	h	$= 6{\cdot}63 \times 10^{-34}$ J s
Boltzmann constant	k	$= 1{\cdot}38 \times 10^{-23}$ J K^{-1}
Speed of light *in vacuo*	c	$= 3{\cdot}00 \times 10^{8}$ m s^{-1}
Permittivity of free space	ε_o	$= 8{\cdot}85 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
Stefan constant	σ	$= 5{\cdot}67 \times 10^{-8}$ W m^{-2} K^{-4}
Wien constant	W	$= 2{\cdot}90 \times 10^{-3}$ m K

T/K = θ/°C + 273·15

1 u = $1{\cdot}66 \times 10^{-27}$ kg

Mathematical Requirements

Approximately 40% of the examination will test your mathematical competence. This list below provides the areas that you need to be proficient in. For further information please refer to pp.187-196 of the student text book. If there are any areas of this that you feel you need support with please ask your physics teacher as soon as you can.

Arithmetic & Numerical Calculation

- Recognise and make use of appropriate units in calculations
- Recognise and use expressions in decimal and standard form
- Use ratios, fractions and percentages
- Estimate results
- Use calculators to find and use power functions
- Use calculators to handle $\sin x$, $\cos x$, $\tan x$ when x is expressed in degrees or radians

Handling data

- Use an appropriate number of significant figures
- Find arithmetic means
- Understand simple probability
- Make order of magnitude calculations
- Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined by addition, subtraction, multiplication, division and raising to powers

Algebra

- Understand and use the symbols: =, <, <<, >>, >, ∝, ≈, Δ
- Change the subject of an equation, including non-linear equations
- Substitute numerical values into algebraic equations using appropriate units for physical quantities
- Solve algebraic equations, including quadratic equations

Graphs

- Translate information between graphical, numerical and algebraic forms
- Plot two variables from experimental or other data
- Understand that $y = mx + c$ represents a linear relationship
- Determine the slope and intercept of a linear graph
- Calculate rate of change from a graph showing a linear relationship
- Draw and use the slope of a tangent to a curve as a measure of rate of change
- Distinguish between instantaneous rate of change and mean rate of change
- Understand the possible physical significance of the area between a curve and the x-axis and be able to calculate it or estimate it by graphical methods as appropriate
- Apply the concepts underlying calculus (but without requiring the explicit use of derivatives or integrals) by solving equations involving rates of change
- using a graphical method or spreadsheet modelling
- Sketch relationships which are modelled by: $y=kx$; $y=kx^{-1}$; $y=kx^2$; $y=kx^{-2}$; $y=\sin x$; $y=\cos x$

Geometry and trigonometry

- Use angles in regular 2D and 3D structures
- Visualise and represent 2D and 3D forms, including 2D representations of 3D objects
- Calculate areas of triangles, circumferences and areas of circles, surface areas and volumes of rectangular blocks, cylinders and spheres
- Use Pythagoras' theorem, and the angle sum of a triangle
- Use $\sin$, $\cos$ and $\tan$ in physical problems
- Use of small angle approximations including $\sin\theta \approx \theta$, $\tan\theta \approx \theta$, $\cos\theta \approx 1$ for small θ where appropriate
- Understand the relationship between degrees and radians and translate from one to the other

Standard Units

Modern Physics uses the S.I. system of units. These are based on six BASE units:

Quantity	Unit
mass	Kilogram (kg)
length	Metre (m)
time	second (s)
electric Current	Ampere (A)
Temperature	Kelvin (K)
Amount of substance	mole (mol)

All other units are then derived from these.
Some of the more common units of measurement you will meet are:

Area	square metre : m^2
Volume	cubic metre : m^3
Speed	metre per second : ms^{-1}
Acceleration	metre per second squared : ms^{-2}
Frequency	Hertz : Hz
Force	Newton : N
Pressure	Pascal : Pa
Energy	Joule : J
Charge	Coulomb : C
Electric p.d.	Volt : V
Electrical resistance	Ohm : Ω

For more, see http://physics.nist.gov/cuu/Units/units.html

Common vectors & scalars

Examples of ***scalars***:
Distance , speed , mass , energy , temperature , time , density , pressure

Examples of ***vectors***:
Velocity , acceleration , displacement , force , momentum.

Standard Form – 'Powers of ten'

$10^0 = 1$

$10^1 = 10$

$10^2 = 10x10 = 100$

$10^3 = 10x10x10 = 1,000$

$10^{-1} = 1/10 = 0.1$

$10^{-2} = 1/100 = 0.01$

$10^{-3} = 1/1,000 = 0.001$

10^{12} ⇔ tera (T)

10^9 ⇔ giga (G)

10^6 ⇔ mega (M)

10^3 ⇔ kilo (k)

10^{-3} ⇔ milli (m)

10^{-6} ⇔ micro (μ)

10^{-9} ⇔ nano (n)

10^{-12} ⇔ pico (p)

see also: http://physics.nist.gov/cuu/Units/index.html

A/S Physics Formulae

Here is the list of formulae that will be supplied in the data booklet in the examinations, along with the supplied mathematical information on the following page.

AS

$\rho = \frac{m}{V}$

$v = u + at$

$x = \frac{1}{2}(u+v)t$

$x = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2ax$

$\Sigma F = ma$

$W = Fx\cos\theta$

$\Delta E = mg\Delta h$

$E = \frac{1}{2}kx^2$

$E = \frac{1}{2}mv^2$

$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$P = \frac{W}{t} = \frac{\Delta E}{t}$

$I = \frac{\Delta Q}{\Delta t}$

$I = nAve$

$R = \frac{\rho l}{A}$

$R = \frac{V}{I}$

$P = IV$

$V = E - Ir$

$\frac{V}{V_{\text{total}}}\left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}}\right) = \frac{R}{R_{\text{total}}}$

$c = f\lambda$

$T = \frac{1}{f}$

$\lambda = \frac{ay}{D}$

$d\sin\theta = n\lambda$

$n_1 v_1 = n_2 v_2$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$E_{k\,\text{max}} = hf - \phi$

$\lambda_{\text{max}} = WT^{-1}$

$P = A\sigma T^4$

$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)		up (u)	down (d)
charge (e)	-1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1		0	0

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	µ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

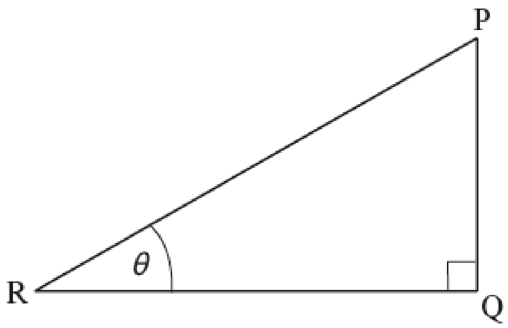
Areas and Volumes

Area of a circle = $\pi r^2 = \frac{\pi d^2}{4}$

Area of a triangle = $\frac{1}{2}$ base × height

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{QR}{PR}, \quad \tan\theta = \frac{PQ}{QR}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + QR^2$$

The Greek Alphabet

For personal reference only. Physics borrows lots of these characters…

small case	Name	Upper case
α	Alpha	Α
β	Beta	Β
γ	Gamma	Γ
δ	Delta	Δ
ε	Epsilon	Ε
ζ	Zeta	Ζ
η	Eta	Η
θ	Theta	Θ
ι	Iota	Ι
κ	Kappa	Κ
λ	Lambda	Λ
μ	Mu	Μ
ν	Nu	Ν
ξ	Xi	Ξ
ο	Omicron	Ο
π	Pi	Π
ρ	Rho	Ρ
σ	Sigma	Σ
τ	Tau	Τ
υ	Upsilon	Υ
φ	Phi	Φ
χ	Chi	Χ
ψ	Psi	Ψ
ω	Omega	Ω

Ph1 – 1 Basic Physics

Page ref	You need to demonstrate knowledge and understanding of…		☺
10	**a**	the 6 essential base SI units (kg, m, s, A, mol, K)	
10-11	**b**	representing units in terms of the 6 base SI units and their prefixes	
12	**c**	checking equations for homogeneity using units	
12-13	**d**	the difference between scalar and vector quantities and to give examples of each – displacement, velocity, acceleration, force, speed, time, density, pressure	
13-15	**e**	the addition and subtraction of coplanar vectors, and perform mathematical calculations limited to **two** perpendicular vectors	
15-16	**f**	how to resolve a vector into two perpendicular components	
16-17	**g**	the concept of density and how to use the equation $\rho = \frac{m}{V}$ to calculate mass, density and volume	
17-18	**h**	what is meant by the turning effect of a force	
18-19	**i**	the use of the principle of moments	
19-20	**j**	the use of centre of gravity, for example in problems including stability: identify its position in a cylinder, sphere and cuboid (beam) of uniform density	
20-22	**k**	when a body is in equilibrium the resultant force is zero and the net moment is zero, and be able to perform simple calculations	

Ph1 – 2 Kinematics

Page ref		You need to demonstrate knowledge and understanding of…	☺
24-27	**a**	what is meant by displacement, mean and instantaneous values of speed, velocity and acceleration	
24-27	**b**	the representation of displacement, speed, velocity and acceleration by graphical methods	
24-27	**c**	the properties of displacement-time graphs, velocity-time graphs, and interpret speed and displacement-time graphs for non-uniform acceleration	
28	**d**	how to derive and use equations which represent uniformly accelerated motion in a straight line	
29-33 44-46	**e**	how to describe the motion of bodies falling in a gravitational field with and without air resistance - terminal velocity	
29-33	**f**	the independence of vertical and horizontal motion of a body moving freely under gravity	
29-33	**g**	the explanation of the motion due to a uniform velocity in one direction and uniform acceleration in a perpendicular direction, and perform simple calculations	

Ph1 – 3 Dynamics

Page ref		You need to demonstrate knowledge and understanding of…	☺
36-41	**a**	the concept of force and Newton's 3rd law of motion	
43	**b**	how free body diagrams can be used to represent forces on a particle or body	
43	**c**	the use of the relationship $\sum F = ma$ in situations where mass is constant	
36	**d**	the idea that linear momentum is the product of mass and velocity	
39	**e**	the concept that force is the rate of change of momentum, applying this in situations where mass is constant	
37-41	**f**	the principle of conservation of momentum and use of it to solve problems in 1-D involving elastic collisions (no loss of K.E.) and inelastic collisions (where there is a loss of K.E.)	

Ph1 – 4 Energy Concepts

Page ref		You need to demonstrate knowledge and understanding of…	☺
50	**a**	the idea that work is the product of a force and distance moved in the direction of the force when the force is constant: $work\ done = F\ x$	
51-52	**b**	the calculation of the work done for constant forces, when the force is not along the line of motion: $work\ done = F\ x\ cos\theta$	
52-54	**c**	the principle of conservation of energy including knowledge of: gravitational potential energy ($GPE = mg\Delta h$); elastic potential energy ($EPE = ½kx^2$) and kinetic energy ($KE = ½\ mv^2$)	
53	**d**	the work-energy relationship: $Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$	
55	**e**	power being the rate of energy transfer	
56	**f**	dissipative forces for example, friction and drag cause energy to be transferred from a system and reduce the overall efficiency of the system	
56	**g**	the equation: $efficiency = \frac{useful\ energy\ transfer}{total\ energy\ input} \times 100\%$	

Ph1 – 5 Solids Under Stress

Page ref		You need to demonstrate knowledge and understanding of…	☺
58	**a**	Hooke's law and use $F = kx$ where the spring constant k is the force per unit extension	
59	**b**	for materials tensile stress is $\sigma = \frac{F}{A}$; tensile strain is $\varepsilon = \frac{\Delta l}{l}$; and Young's Modulus is $E = \frac{\sigma}{\varepsilon}$ when Hooke's Law is obeyed.	
60	**c**	the work done in deforming a solid being equal to the area under a force-extension graph, which is $F = kx$ if Hooke's law is obeyed	
61-66	**d**	the classification of solids as crystalline, amorphous (to include glasses and ceramics) and polymeric	
61-63	**e**	the features of a force-extension (or stress-strain) graph for a **metal, such as copper**, to include: elastic and plastic strain; the effects of dislocations, and the strengthening of metals by introducing barriers to dislocation movement, such as foreign atoms, other dislocations, and more grain boundaries; necking and ductile fracture	
63-64	**f**	the features of a force-extension (or stress-strain) graph for a **brittle material such as glass**, to include: elastic strain and obeying Hooke's law up to fracture; brittle fracture by crack propagation; the effect of surface imperfections on breaking stress, and how breaking stress can be increased by reducing surface imperfections (as in thin fibres) or by putting surface under compression (as in toughened glass or pre-stressed concrete)	
65-66	**g**	the features of a force-extension (or stress-strain) graph **for rubber**, to include: Hooke's law only approximately obeyed; low Young modulus and the extension due to straightening of chain molecules against thermal opposition; hysteresis	

Ph1 – 6 Radiation and Stars

Page ref		You need to demonstrate knowledge and understanding of…	☺
70-71 75-76	**a**	the idea that the stellar spectrum consists of a continuous emission spectrum, from the dense gas of the surface of the star, and a line absorption spectrum arising from the passage of the emitted electromagnetic radiation through the tenuous atmosphere of the star	
71-72 74	**b**	the idea that bodies which absorb all incident radiation are known as black bodies and that stars are very good approximations to black bodies	
72	**c**	the shape of the black body spectrum and that the peak wavelength is inversely proportional to the absolute temperature: T(K) =θ(°C) + 273.15)	
72	**d**	Wien's displacement law, Stefan's law and the inverse square law to investigate the properties of stars – luminosity, size, temperature and distance	
77-78	**e**	the meaning of multi-wavelength astronomy and that by studying a region of space at different wavelengths (different photon energies) the different processes which took place there can be revealed	

Ph1 – 7 Particles and Nuclear Structure

Page ref		You need to demonstrate knowledge and understanding of…	☺
80	**a**	the idea that matter is composed of quarks and leptons and that there are three generations of quarks and leptons	
81-82	**b**	the idea that antiparticles exist for the particles in the table below and that the properties of an antiparticle are identical to those of its corresponding particle apart from having opposite charge, and that particles and antiparticles annihilate	
81	**c**	symbols for particles and antiparticles of electrons, quarks and hadrons	
82-83	**d**	the idea that quarks and antiquarks are never observed in isolation, but are bound into composite particles called hadrons: baryons (3 quarks); antibaryons (3 antiquarks) or mesons (quark-antiquark pairs)	
83	**e**	the quark compositions of the neutron and proton	
82-83	**f**	how to use data in the table below to suggest the quark make-up of less well known first generation baryons and of charged pions	
83-84	**g**	the properties of the four forces or interactions experienced by particles (summarised in second table below)	
84-85	**h**	how to apply conservation of charge, lepton number and baryon number (or quark number) to given simple reactions	
82-85	**i**	the idea that neutrino involvement and quark flavour changes are exclusive to weak interactions	

	leptons		quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)	up (u)	down (d)
charge (e)	-1	0	$+\frac{2}{3}$	$-\frac{1}{3}$

Interaction	Experienced by	Range	Comments
gravitational	all matter	infinite	very weak – negligible except between large objects such as planets
weak	all leptons, all quarks, so all hadrons	very short	only significant when the e-m and strong interactions do not operate
electromagnetic (e-m)	all charged particles	infinite	also experienced by neutral hadrons, as these are composed of quarks
strong	all quarks, so all hadrons	short	

Ph2 – 1 Electrical Conduction

Page ref		You need to demonstrate knowledge and understanding of…	☺
94	**a**	the fact that the unit of charge is the coulomb (C), and that an electron's charge, e, is a very small fraction of a coulomb	
94-95	**b**	the fact that charge can flow through certain materials, called conductors	
95	**c**	electric current being the rate of flow of charge	
95-96	**d**	the use of the equation: $I = \frac{\Delta Q}{\Delta t}$	
95	**e**	current being measured in amperes (A), where A = Cs^{-1}	
96-97	**f**	the mechanism of conduction in metals as the drift of free electrons	
96	**g**	the derivation and use of the equation $I = nAve$ for free electrons	

Ph2 – 2 Electrical resistance

Page ref		You need to demonstrate knowledge and understanding of…	☺
100	**a**	the definition of potential difference	
100	**b**	the idea that potential difference is measured in volts (V) where $V = JC^{-1}$	
101-102	**c**	the characteristics of $I - V$ graphs for the filament of a lamp, and a metal wire at constant temperature	
102-103	**d**	Ohm's law, the equation $V = IR$ and the definition of resistance	
102-103	**e**	resistance being measured in ohms (Ω), where $\Omega = VA^{-1}$	
101-103	**f**	the application of: $P = IV = I^2R = \frac{V^2}{R}$	
103, 105	**g**	collisions between free electrons and ions gives rise to electrical resistance, and electrical resistance increases with temperature	
104	**h**	the application of: $R = \frac{\rho l}{A}$	
105	**i**	the idea that the resistance of metals varies almost linearly with temperature over a wide range	
105	**j**	the idea that ordinarily, collisions between free electrons and ions in metals increase the random vibration energy of the ions, so the temperature of the metal increases	
106	**k**	what is meant by superconductivity, and superconducting transition temperature	
106	**l**	the fact that most metals show superconductivity, and have transition temperatures a few degrees above absolute zero (0K ie –273 °C)	
106	**m**	certain materials (high temperature superconductors) having transition temperatures above the boiling point of nitrogen (–196 °C)	
106	**n**	some uses of superconductors for example, MRI scanners and particle accelerators	

Ph2 – 3 D.C. Circuits

Page ref		You need to demonstrate knowledge and understanding of…	☺
112-113	**a**	the idea that the current from a source is equal to the sum of the currents in the separate branches of a parallel circuit, and that this is a consequence of conservation of charge	
112-113	**b**	the sum of the potential differences across components in a series circuit is equal to the potential difference across the supply, and that this is a consequence of conservation of energy	
112-114	**c**	potential differences across components in parallel are equal	
114-115	**d**	the application of equations for the combined resistance of resistors in series and parallel	
115-117	**e**	the use of a potential divider in circuits (including circuits which contain LDRs and thermistors)	
118	**f**	what is meant by the emf of a source	
118	**g**	the unit of emf is the volt (V), which is the same as that of potential difference	
118-119	**h**	the idea that sources have internal resistance and to use the equation $V = E - Ir$	
119-120	**i**	how to calculate current and potential difference in a circuit containing one cell or cells in series	

Ph2 – 4 The Nature of Waves

Page ref		You need to demonstrate knowledge and understanding of…	☺
124	**a**	the idea that a progressive wave transfers energy without any transfer of matter	
124-125	**b**	the difference between transverse and longitudinal waves	
125, 128	**c**	the term polarisation	
126-127	**d**	the terms in phase and in antiphase	
126-127	**e**	the terms displacement, amplitude, wavelength, frequency, period and velocity of a wave	
126-127	**f**	graphs of displacement against time, and displacement against position for transverse waves only	
(?)	**g**	the equation $c = f\lambda$	
127	**h**	the idea that all points on wavefronts oscillate in phase, and that wave propagation directions (rays) are at right angles to wavefronts	

Ph2 – 5 Wave Properties

Page ref	You need to demonstrate knowledge and understanding of…		☺
130	**a**	diffraction occuring when waves encounter slits or obstacles	
130	**b**	the idea that there is little diffraction when λ is much smaller than the dimensions of the obstacle or slit	
130	**c**	the idea that if λ is equal to or greater than the width of a slit, waves spread as roughly semi-circular wavefronts, but if λ is less than the slit width the main beam spreads through less than 180°	
131	**d**	how two source interference occurs	
133	**e**	the historical importance of Young's (Double Slit) experiment	
131	**f**	the principle of superposition, giving appropriate sketch graphs	
131-132	**g**	the path difference rules for constructive and destructive interference between waves from in phase sources	
133	**h**	the use of: $\lambda = \frac{a\Delta y}{D}$	
134-136	**i**	the derivation and use of $d \sin\theta = n\lambda$ for a diffraction grating	
134-136	**j**	the idea that for a diffraction grating a very small d makes beams ("orders") much further apart than in Young's experiment, and that the large number of slits makes the bright beams much sharper	
133	**k**	the idea that coherent sources are monochromatic with wavefronts continuous across the width of the beam and, (when comparing more than one source) with a constant phase relationship	
133-134	**l**	examples of coherent and incoherent sources	
133	**m**	the idea that for two source interference to be observed, the sources must have a zero or constant phase difference and have oscillations in the same direction	
136-137	**n**	the differences between stationary and progressive waves	
136-138	**o**	the idea that a stationary wave can be regarded as a superposition of two progressive waves of equal amplitude and frequency, travelling in opposite directions, and that the internodal distance is $\frac{\lambda}{2}$	

Ph2 – 6 Refraction of Light

Page ref		You need to demonstrate knowledge and understanding of…	☺
145	**a**	the refractive index, n, of a medium being defined as $n = \frac{c}{v}$ in which v is the speed of light in the medium and c is the speed of light in a vacuum	
146	**b**	the use of the equations: $n_1 v_1 = n_2 v_2$ and $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (regarded as Snell's law)	
145-146	**c**	how Snell's law relates to the wave model of light propagation and for diagrams of plane waves approaching a plane boundary obliquely, and being refracted	
146-147	**d**	the conditions for total internal reflection	
147	**e**	the derivation and use of the equation for the critical angle: $n_1 \sin\theta_c = n_2$	
148-149	**f**	how to apply the concept of total internal reflection to multimode optical fibres	
149	**g**	the problem of multimode dispersion with optical fibres in terms of limiting the rate of data transfer and transmission distance	
150	**h**	how the introduction of monomode optical fibres has allowed for much greater transmission rates and distances	

Ph2 – 7 Photons

Page ref		You need to demonstrate knowledge and understanding of…	☺
154	**a**	the fact that light can be shown to consist of discrete packets (photons) of energy	
154	**b**	how the photoelectric effect can be demonstrated	
155	**c**	how a vacuum photocell can be used to measure the maximum kinetic energy, $E_{k\,max}$, of emitted electrons in eV and hence in J	
155	**d**	the graph of $E_{k\,max}$ against frequency of illuminating radiation	
155-156	**e**	how a photon picture of light leads to Einstein's equation, $E_{k\,max} = hf - \phi$, and how this equation correlates with the graph of $E_{k\,max}$ against frequency	
157	**f**	the fact that the visible spectrum runs approximately from 700 nm (red end) to 400 nm (violet end) and the orders of magnitude of the wavelengths of the other regions of the electromagnetic spectrum	
157	**g**	typical photon energies for the radiations of (f) above	
158-159	**h**	how to produce line emission and line absorption spectra from atoms	
159	**i**	the appearance of such spectra as seen in a diffraction grating	
157-159	**j**	simple atomic energy level diagrams, together with the photon hypothesis, line emission and line absorption spectra	
157-158	**k**	how to determine ionisation energies from an energy level diagram	
160-161	**l**	the demonstration of electron diffraction and that particles have a wave-like aspect	
161-162	**m**	the use of the relationship $p = \frac{h}{\lambda}$ for both particles of matter and photons	
162	**n**	the calculation of radiation pressure on a surface absorbing or reflecting photons	

Ph2 – 8 LASERs

Page ref		You need to demonstrate knowledge and understanding of…	☺
166-167	**a**	the process of stimulated emission and how this process leads to light emission that is coherent	
167	**b**	the idea that a population inversion ($N_2 > N_1$) is necessary for a laser to operate	
167	**c**	the idea that a population inversion is not (usually) possible with a 2-level energy system	
167-168	**d**	how a population inversion is attained in 3 and 4-level energy systems	
167-169	**e**	the process of pumping and its purpose	
168-169	**f**	the structure of a typical laser i.e. an amplifying medium between two mirrors, one of which partially transmits light	
169-170	**g**	the advantages and uses of a semiconductor laser i.e. small, cheap, far more efficient than other types of laser, and it is used for CDs, DVDs, telecommunication etc.	