1st year Physics lesson and test schedule:

The table below gives you the exact order of lessons. The week for each lesson is just a rough guide as timings can be altered due to things like progress review days where some lessons are postponed

Week	Topic	Theoretical physics	Topic	Applied physics
1		Enrolment week – no lessons		
2		Enrolment week – no lessons		
3	1 – Particle physics	1.1.1 - Atomic structure	4 - Mechanics	4.1.1 - Scalars and vectors
		1.1.2 - Stable and unstable nuclei		4.1.2 - Forces in equilibrium
4		Induction test		4.1.3 - Moments
		1.1.3 - Antiparticles and photons		4.1.4 - Centre of mass and moments
5		1.1.4 - Hadrons and leptons		4.1.5 - Problems with two pivots
		1.1.5 - Quarks and antiquarks		4.2.1 - Uniform acceleration
6		1.1.6 - Strange particles and conservation of properties		4.2.2 - Displacement time graphs
		1.1.7 - Particle interactions		4.2.3 - Velocity time graphs
7		**Particles Revision lesson + Cloud chambers**		4.2.4 - Acceleration time graphs
		Particles Revision lesson		4.2.5 - Newton's laws of motion
8		**Particles test**		4.2.6 - Acceleration due to gravity
		0.1.1 and 0.1.2 How are practical skills assessed and SI units		4.3.1 - Projectile motion
9		0.1.3 and 0.1.4 – Experiment design and Micrometres and callipers		4.3.2 - Drag lift and terminal speed
		0.1.5 – Data and tables		4.3.3 - Conservation of momentum
		Half term		
10	0 - Practical skills	0.1.6 and 0.1.7 – Drawing manipulating straight line graphs		4.3.4 - Force, momentum, and impulse
		0.1.8 – Sources of error and uncertainty		4.3.5 - Work and power
11		0.1.9 – Calculating uncertainties		4.3.6 - Conservation of energy
		0.1.10 – Evaluating and concluding		**Required practical 3**
12		**Practical skills revision lesson**		Practice practical questions lesson
		Practical skills revision lesson		**Mechanics revision lesson**
13		**Practicals test + Particles**		**Mechanics revision lesson**
	2 – Quantum Phenomena	2.1.1 - Intro to the photoelectric effect		**Mechanics test**
14		2.1.2 – Calculations with the photoelectric effect	5 - Materials	5.1.1 - Density
		2.1.3 - Energy levels in atoms part 1		5.1.2 - Hooke's law
15		2.1.4 - Energy levels in atoms part 2		5.1.3 – Elastic potential energy
		2.1.5 - Wave particle duality		5.1.4 - Stress and strain
16		**Mid year exam revision**		5.1.5 - Youngs modulus
		Mid year exam revision		5.1.6 - Brittle materials
		Christmas		
17		**Mid year exam revision**		**Required practical 4**
		Mid year exam revision		Practice practical questions lesson
18		**Mid year exam revision**		**Mid year exam revision**
		Mid year exam revision		**Mid year exam revision**
19		**MID YEAR EXAM (primarily on Quantum Phenomena and Material and a little on everything else)**		
	3 - Waves	3.1.1 - Transverse and longitudinal waves	6 - Electricity	6.1.1 - Circuit basics
20		3.1.2 - Polarisation of waves		6.1.2 - Current, voltage and resistance in series
		3.1.3 - Wave speed		6.1.3 - Current, voltage and resistance in parallel
21		3.1.4 - Superposition and stationary waves		6.1.4 – Solving tricky circuit combinations
		3.1.5 - Investigating resonance		**Go through mid-year**
22		3.2.1 - Diffraction		6.2.1 – IV characteristics
		3.2.2 - Two source interference		6.2.2 – Resistivity and superconductors
		Half term		
23		3.2.3 - Diffraction gratings	6 - Electricity	6.2.3 - Power and electrical energy
		3.3.1 - Refractive index		6.2.4 - EMF and internal resistance
24		3.3.2 - Critical angle and TIR		6.2.5 - Potential dividers
		Required practical 1A		**Required practical 5**
25		**Required practical 1B**		Practice practical questions lesson
		Practice practical questions lesson		**Required practical 6**
26		**Required practical 2A**		Practice practical questions lesson
		Required practical 2B		**Electricity revision lesson**
27		Practice practical questions lesson		**Electricity revision lesson**
		Waves revision lesson		**Electricity revision lesson**
28		**Waves revision lesson**		**Electricity revision lesson**
		Waves revision lesson		**Electricity revision lesson**
		Easter		
29		**Transfer mock revision lesson**		**Transfer mock revision lesson**
		Transfer mock revision lesson		**Transfer mock revision lesson**
30		**TRANSFER MOCK (primarily on Waves and Electricity and a little on everything else)**		
31		**Transfer exam revision lesson**		**Transfer exam revision lesson**
		Transfer exam revision lesson		**Transfer exam revision lesson**
32		**Study leave**		**Study leave**
33		**Study leave/Transfer exam**		**Study leave/Transfer exam**
		Half term		
34		**WEX week**		**WEX week**
35	7 – Further mechanics	7.2.1 – Simple harmonic motion intro	7 – Further mechanics	7.1.1 and 7.1.2 – Radians and angular speed
		7.2.2 and 7.2.3 – Calculations for SHM and energy intro		7.1.3 and 7.1.4 – Centripetal force and acceleration
36		7.2.4 – Simple harmonic oscillators		7.1.5 – Motion in a vertical circle
		7.2.5 and 7.2.6 – Free and force vibrations and damping intro		7.1.6 – Circular motion at an angle
37		**Required practical 7A**		**Required practical 7B**
		Practice practical questions lesson		Practice practical questions lesson
38		Glider project		Glider project
		Glider project		Glider project
39		Glider project		Glider project
		Glider project		Glider project
		Summer		

2nd year Physics lesson and test schedule:

The table below gives you the exact order of lessons. The week for each lesson is just a rough guide as timings can be altered due to things like progress review days where some lessons are postponed

Week	Advancing physics		Exploring physics	
1	Enrolment week – no lessons			
2	Enrolment week – no lessons			
3	11 - Magnets	11.1.1 - Magnetic flux density	7 - FM	Further mech recap 1
		11.1.2 - Forces on charged particles		Further mech recap 2
4		11.1.3 - Electromagnetic induction		**Further mech assessment + Practical skills**
		11.1.4 - Faraday's law and Lenz's law	8 – Thermal physics	8.1.1 - Specific heat capacity
5		11.1.5 - Alternating current		8.1.2 and 8.1.3 - Specific latent heat and tricky thermal transfer problems
		11.1.6 - Transformers		8.2.1 - Absolute zero and kelvin temperature scale
6		**Required practical 10**		8.2.2 - Pressure law
		Practice practical questions lesson		8.2.3 - Boyles law
7		**Required practical 11**		8.2.4 - Charles' law
		Practice practical questions lesson		8.2.5 - Molar mass an Avogadro's constant
8		**Revision**		8.2.6 - The ideal gas equation
		Revision		8.2.7 - Work done on a gas
9		**Revision**		8.3.1 - Intro to kinetic theory
		Magnets assessment + Waves		8.3.2 and 8.3.3 - Deriving and using the kinetic theory equation
	Half term			
10	12 – Nuclear physics	12.1.1 - Measuring nuclear radius		8.3.4 - Calculating the energy of a gas
		12.1.3 - Properties of nuclear radiation		**Required practical 8A**
11		12.1.4 - Background radiation and intensity		**Required practical 8B**
		12.2.1 - Exponential law of decay		Practice practical questions lesson
12		12.2.2 - Half-life and its applications		**Revision**
		12.2.3 - Nuclear decay		**Revision**
13		12.3.1 - Mass defect and binding energy		**Thermal assessment + Further Mech**
		12.3.2 - Nuclear fission and fusion	9 - Fields	9.1.1 and 9.1.2 Intro to gravitational fields and Gravitational force
14		12.3.3 - Nuclear fission reactors		9.1.3 - Gravitational field strength
		Required practical 12		9.1.4 - Gravitational potential part 1
15		Practice practical questions lesson		9.1.5 - Gravitational potential part 2
		Revision		9.1.6 - Satellite orbits
16		**Revision**		9.1.7 - Orbital equations
		Revision		9.2.1 and 9.2.2 - Intro to electric fields and Electric force
	Christmas			
17		13.1.1 - Lenses		9.2.3 - Electric field strength
		13.1.2 - Optical telescopes		9.2.4 - Charged particles fired into a uniform field
18		13.1.3 - Comparing telescopes		9.2.5 - Electric potential part 1
		13.1.4 - Non-optical telescopes		9.2.6 - Electric potential part 2
19		13.1.5 - Parallax and parsecs		9.2.7 - Comparing electric and gravitational fields
		13.2.1 - Magnitude		**Revision**
20		13.2.2 - Stars as blackbodies		**Revision**
	Mid year exam revision			**Fields assessment + Thermal**
21	**Mid year exam revision**		**Mid year exam revision**	
	Mid year exam revision		**Mid year exam revision**	
22	**MID YEAR EXAM WEEK (Physics exam will be on paper 1 content)**			
	Half term			
23	13 – Astrophysics	13.2.3 - Stellar spectral classes	10 - Capacitors	10.1.1 - Capacitors
		13.2.4 - Hertzsprung-Russell diagram		10.1.2 - Energy stored by capacitors
24		13.2.5 - Evolution of sun like stars		10.1.3 - Dielectrics
		13.3.1 - Supernovae and Neutron stars		10.1.4 - Charging and discharging
25		13.3.2 - Black holes and quasars		10.1.5 -Time constant and time to halve
		Go through mid-year		**Required practical 9A**
26		13.3.3 - The doppler effect and red shift		**Required practical 9B**
		13.3.4 - The big bang theory		Practice practical questions lesson
27		13.3.5 - Detection of binary stars and exoplanets		**Revision**
		Revision		**Revision**
28		**Revision**		**Revision**
		Revision		**Revision**
	Easter			
29	**PAPER 2 MOCK**			
30	**Revision lesson**		**Revision lesson**	
	Revision lesson		**Revision lesson**	
31	**PAPER 3 MOCK**			
32	**Revision lesson**		**Revision lesson**	
	Revision lesson		**Revision lesson**	
33	**Study leave starts**		**Study leave starts**	
	Half term			

0. Practical skills

Code	Title	Content
0.1.1	How are practical skills assessed	• Understand how practical skills will be asses in both the practical endorsement and in paper 3
0.1.2	SI units and prefixes	• Know the fundamental (base) units of mass, length, time, quantity of matter, temperature, electric current and their associated SI units. The fundamental unit of light intensity, the candela, is excluded. • Know SI units derived from the base units • Students should be able to use the prefixes: T, G, M, k, c, m, μ, n, p, f, Students should be able to convert between different units of the same quantity, eg J and eV, J and kW h.
0.1.3	Experiment design	• When planning an experiment be able to make predictions, choose appropriate equipment, write risk assessments and method • Be able to identify independent, dependent, control variables • Choosing appropriate equipment, precision of equipment • Identify risks and how to minimise them • Know how to evaluate an experiment. Does experiment meet aims? Is method clear? Is equipment appropriate?
0.1.4	Micrometres and callipers	• Know how to use and read a micrometer • Know how to use and read a vernier calliper
0.1.5	Data and tables	• Know the difference between discrete, continuous, categoric and ordered (ordinal) • Correctly drawing and filling in tables • Estimating quantities and orders of magnitude • Averaging repeated results and avoiding anomalies
0.1.6	Drawing graphs	• Correctly plotting graphs • Identifying patterns in results
0.1.7	Drawing manipulating straight line graphs	• Measuring gradients, y-intercepts and using y=mx+c • Draw log graphs (For second years only)
0.1.8	Sources of error and uncertainty	• Know what systematic and random errors are and how to reduce them • Know how to reduce uncertainty by repeating an averaging, using appropriate equipment, calibrating • Averaging repeated results and avoiding anomalies • Calculating correct numbers of significant figures
0.1.9	Calculating uncertainties	• Know how to calculate absolute, fractional and percentage uncertainties • Know how to combine uncertainties when adding or subtracting, multiplying or dividing, raising to a power • Represent uncertainty in a data point on a graph using error bars • Determine the uncertainties in the gradient and intercept of a straight-line graph
0.1.10	Evaluating and concluding	• Comparing your result against another by using percentage differences • Be able to evaluate your results by considering are your results precise, resolution, repeatable, reproducible, valid and accurate (you need to know these definitions) • Be able to evaluate your method. Have you controlled variables? Are there anomalous results? Could you have reduced uncertainties? • Know how to draw conclusions and being able to identify whether your data supports the conclusion

1. Particles and Radiation

Nugget	Title	Content
1.1.1	Atomic structure SPECIFICATION REFERENCE 3.2.1.1	• Understand that an atom is made up of protons, neutrons and electrons • Know the mass and charge of protons, neutrons and electrons in relative and SI units • Know that proton number, Z, is the number of protons • Know that nucleon number, A, is the total number of protons and neutrons • Be able to use nuclide notation • Know what specific charge means and how to calculate the specific charge of individual particles, nuclei and ions • Know that isotopes have the same proton number but different nucleon numbers • Know how isotopic data can be used
1.1.2	Stable and unstable nuclei SPECIFICATION REFERENCE 3.2.1.2	• Understand the role of the strong nuclear force in keeping the nucleus stable • Know how the strong nuclear force varies with nucleon separation short range attraction up to approximately 3fm, very short range repulsion closer than approximately 0.5fm) • Understand that unstable nuclei can undergo alpha or beta decay • Know the equations for alpha and beta-minus decay, including the need for the neutrino • Understand why observations of beta decay led to the hypothesis of neutrinos, due to the conservation of energy
1.1.3	Antiparticles and photons SPECIFICATION REFERENCE 3.2.1.3	• Understand the photon model of electromagnetic radiation • Understand the equation $E=hf=hc/\lambda$, where h is the planck constant • Know that for every particle, there is a corresponding antiparticle • Be able to compare the masses, charges and rest energies (in MeV) of particles and anti-particles • Know the antiparticles of the proton, neutron, electron and electron neutrino • Understand the pair production and annihilation processes and be able to calculate the energies involved
1.1.4	Hadrons and leptons SPECIFICATION REFERNECE 3.2.1.5 AND 3.2.1.6	• Know that hadrons are subject to the strong interaction • Know that there are two classes of hadrons – baryons (eg. Protons and neutron) with anti- baryons (anti-protons and anti-neutrons) and mesons (eg. Pions and kaons) • Know that the proton is the only stable baryon and that other baryons decay into it • Know that the baryon number of a quantum number that must be conserved • Know the decay of the neutron • Know that the pion is the exchange particle of the strong nuclear force • Know that kaons decay into pions • Know that leptons are subject to the weak interaction • Know that electrons, muons and neutrinos and their antiparticles are lepton • Know that muons decay into electrons • Know that lepton number is a quantum number that must be conserved • Understand conservation of lepton number number for muon leptons and electron lepton
1.1.5	Quarks and antiquarks SPECIFICATION REFERENCE 3.2.1.5 AND 3.2.1.6 AND 3.2.1.7	• Knowledge of the up, down and strange quarks and their antiquarks • Understand the properties of quarks: charge, baryon number and strangeness • Know the quark composition of protons, neutrons, antiprotons, antineutrons, pions and kaons • Decay of a neutron • Understand the change of quark character in $\beta+$ and $\beta-$ decay • Understand that particle physic relies on the collaborative efforts of large teams of scientists and engineers to validate new knowledge
1.1.6	Strange particles and conservation of properties SPECIFICATION REFERENCE 3.2.1.5 AND 3.2.1.7	• Know that STRANGE PARTICLES ARE PRODUCED THROUGH THE STRONG INTERACTION • Know that strangeness is a quantum number that is conserved in strong interactions • Know that strange particles decay through the weak interaction • Know that strangeness can change by +1, 0 or -1 in weak interactions • Understand why strange particles are created in pairs • Know that energy and momentum are always conserved in interactions • Be able to apply conservation laws for charge, baryon number, lepton number and strangeness to particle interactions
1.1.7	Particle interactions SPECIFICATION REFERENCE 3.2.1.4	• Understand the concept of exchange particles to explain forces between elementary particles • Be able to recall four fundamental interactions – gravity, electromagnetic, weak nuclear and strong nuclear • Know that virtual photons are the exchange particles for the electromagnetic force • Know that W+ and W- bosons are exchange particles for the weak interaction • Understand the following weak interactions and the exchange particles involved: $\beta-$ and $\beta+$ decay, electron capture and electron-proton collisions • Be able to draw simple diagrams to represent the above reactions or interactions in terms of incoming particles and exchange particles

2. Quantum Phenomena

Nugget	Title	Content
2.1.1	Intro to the photoelectric effect SPECIFICATION REFERENCE 3.2.2.1	• Explain how the photoelectric effect suggests that electromagnetic waves have a particles nature
2.1.2	Calculations with the photoelectric effect SPECIFICATION REFERENCE 3.2.2.1	• Understand the threshold frequency • Be able to use a photon explanation for the threshold frequency • Understand the work function of a metal • Be able to understand and use the photoelectric equation: $hf=\phi+E_{K(max)}$ • Know that photoelectrons are emitted with a range of kinetic energies, up to a maximum of $E_{K\ (max)}$ • Understand the stopping potential in the photoelectric effect • Explain how changing the intensity and frequency of light affects the photoelectrons?
2.1.3	Energy levels in atoms part 1 SPECIFICATION REFERENCE 3.2.2.2 AND 3.2.2.3	• Be able to use and define the electron volt • Be able to convert between J and eV • Understand and explain the terms ionisation and excitation in atoms • $hf=E_1-E_2$
2.1.4	Energy levels in atoms part 2 SPECIFICATION REFERENCE 3.2.2.2 AND 3.2.2.	• Understand ionisation and excitation in a fluorescent tube • Explain why line spectra are evidence of transitions between discrete energy levels in atoms
2.1.5	Wave particle duality SPECIFICATION REFERENCE 3.2.2.4	• Understand that electromagnetic waves can behave as particles, and particles can show wave like properties • Electron diffraction is an example of a particle behaving as a wave • The photoelectric effect is an example of a wave behaving as a particle • Be able to understand and calculate the de Broglie wavelength of a particles, given by $\lambda=h/mv$, where mv is momentum • Know that our understanding of the nature of matter changes over time, as new theories are evaluated and validated by the scientific community • Understand that electron diffraction suggests the wave nature of particles • Be able to explain how and why diffraction changes when the momentum of a particle changes

3. Waves

Nugget	Title	Content
3.1.1	3.1.1 - Transverse and longitudinal waves SPECIFICATION REFERENCE 3.3.1.1	• Understand that waves cause the particles of the medium they travel through to oscillate • Understand the following characteristics of a wave: amplitude, frequency, wavelength, phase and phase difference • Know that frequency can be calculated using $f=1/T$ • Understand the nature of transverse and longitudinal waves • Know the direction of displacement of particles or field relative to the direction of energy propagation for both transverse and longitudinal waves • Know that electromagnetic waves and waves on a string and examples of transverse waves • Know that sound waves are an example of longitudinal waves
3.1.2	3.1.2 - Polarisation of waves SPECIFICATION REFERNCE 3.3.1.2	• Understand that polarisation is evidence for nature of transverse waves • Be able to give applications of polarisation, eg. Polaroid material and the alignment of aerials
3.1.3	3.1.3 - Wave speed SPECIFICATION 3.3.1.1 AND 3.3.1.2	• Know how to calculate wave speed using $c=f\lambda$ • Understand that all electromagnetic waves travel at the same speed in a vacuum
3.1.4	3.1.4 - Superposition and stationary waves SPECIFICATION REFERENCE 3.3.1.3	• Understand the principle of superposition of waves • Understand what interference is • Know that the phase difference may be measured as angles (in degrees or radians) or as fractions of a cycle • SPECIFICATION REFERENCE 3.3.1.1 AND 3.3.1.3 AND 3.3.2.1 • Understand that stationary waves are formed by two waves of the same frequency travelling in opposite directions • Be able to give a graphical explanation of the formation of stationary waves • Understand that nodes and antinodes are formed by stationary waves, and can be demonstrated using waves on a string • Understand what is meant by harmonics of stationary waves • Know the properties of the harmonics of stationary waves • Understand examples of stationary waves, eg. Waves on a string, microwaves and sound waves
3.1.5	3.1.5 - Investigating resonance SPECIFICATION REFERENCE 3.3.1.3	• Be able to investigate the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string • Know that the frequency of the first harmonic of a string is given by $f=\frac{1}{2l}\sqrt{\frac{T}{\mu}}$
3.2.1	3.2.1 – Diffraction SPECIFICATION REFERENCES 3.3.2.1 AND 3.3.2.2	• Understand the diffraction patterns that are made by light passing through a single slit for both monochromatic and white light • Know that a laser can be used as a source of monochromatic light • Be able to describe the variation of the central maximum in a single-slit diffraction pattern with wavelength and slit width
3.2.2	3.2.2 - Two source interference SPECIFICATION 3.3.2.1	• Understand the concepts of coherence and path difference • Be able to describe and explain interference produces with sound waves and electromagnetic waves • Be able to investigate two source interference of sound waves and electromagnetic waves
3.2.3	3.2.3 - Diffraction gratings SPECIFICATION REFERENCE 3.3.2.1 AND 3.3.2.2	• Understand the interference pattern produced when light is directed through a plane transmission diffraction grating at normal incidence • Be able to investigate interference of light caused by a diffraction grating • Be able to derive and use $d\sin\theta=n\lambda$ where n is the order number • Know the applications of diffraction gratings
3.3.1	3.3.1 - Refractive index SPECIFICATION REFERENCE 3.3.2.3	• Understand what the refractive index of a substance is, and how to calculate it using the formula $n=c/c_s$ • Know that the refractive index of air is approximately 1 • Be able to use Snell's law of refraction for a boundary of two substance $n_1\sin\theta_1=n_2\sin\theta_2$
3.3.2	3.3.2 - Critical angle and TIR SPECIFICATION REFERENCE 3.3.2.3	• Understand what the critical angle is and how to calculate it using $\sin\theta_c=n_2/n_1$ • Understand what total internal reflection is • Understand how step-index optical fibres work, including the function of the cladding • Understand the principles and consequences of pulse broadening and absorption • Understand material and modal dispersion
	Required practical 1A – Stationary waves	
	Required practical 1B – Stationary waves	
	Required practical 2A – Double slit	
	Required practical 2B – Diffraction grating	

4. Mechanics

Nugget	Title	Content
4.1.1	Scalars and vectors SPECIFICATION REFERENCE 3.4.1.1	• Understand the nature of scalar and vector quantities • Be able to give examples of vector and scalar quantities, velocity/speed, force/weight, acceleration, displacement/distance • Be able to use scale drawings to add vectors • Be able to add two perpendicular vectors by calculation • Be able to resolve a vector into two components at right angles to each other, including forces along or perpendicular to an inclined plane
4.1.2	Forces in equilibrium SPECIFICATION REFERENCE 3.4.1.1	• Understand the conditions needed for a body to be in equilibrium • Understand the meaning of equilibrium in the context of an object at rest or moving at a constant velocity • Be able to show that a body is in equilibrium by drawing a closed force triangle • Be able to show that a body is in equilibrium by resolving forces
4.1.3	Moments SPECIFICATION REFERENCE 3.4.1.2	• Be able to calculate the moment of a force about a point • Moment defined as force x perpendicular distance from the point to the line of action of the force • Be able to state the principle of moments and use it to solve problems involving moments, when clockwise and anticlockwise moments balance and system is in equilibrium • Be able to define what a couple is, a pair of equal and opposite coplanar forces, and know that it provides a turning effect • Moment of a couple defined as force x perpendicular distance between the lines of action of the forces • Be able to calculate the moment of a couple
4.1.4	Centre of mass and moments SPECIFICATION REFERENCE 3.4.1.2	• Understand what is meant by the centre of mass of an object • Know that the centre of mass of a uniform solid is at its centre
4.1.5	Problems with two pivots SPECIFICATION REFERENCE 3.4.1.2	• Using moment rules to solve problems with two pivots
4.2.1	Uniform acceleration SPECIFICATION REFERENCE 3.4.1.3	• Understand what is meant by displacement, velocity and acceleration • Be able to use the equations for uniform acceleration • Distinguish between instantaneous and average velocity
4.2.2	Displacement time graphs SPECIFICATION REFERENCE 3.4.1.3	• Be able to represent uniform and non-uniform acceleration using displacement time graphs • Know that $v=\Delta s/\Delta t$ • Understand the significance of the gradient of a displacement-time graph for uniform and non-uniform acceleration • Be able to calculate average and instantaneous velocities
4.2.3	Velocity time graphs SPECIFICATION REFERENCE 3.4.1.3	• Know that $a=\Delta v/\Delta t$ • Be able to represent uniform and non-uniform acceleration using velocity-time graphs • Understand the significance of the area under a velocity-time graph • Understand the significance of the gradient of a velocity time graph for uniform and non-uniform acceleration
4.2.4	Acceleration time graphs SPECIFICATION REFERENCE 3.4.1.3	• Be able to plot acceleration-time graphs • Be able to describe the motion of an object by looking at its acceleration-time graph • Understand that the area under an acceleration time graph is velocity and be able to calculate it
4.2.5	Newton's laws of motion SPECIFICATION REFERENCE 3.4.1.5	• Know Newton's three laws of motion • Be able to apply Newton's three laws of motion to appropriate situations • Be able to solve problems using F=ma for situations where m is constant • Use of free body diagrams
4.2.6	Acceleration due to gravity SPECIFICATION REFERENCE 3.4.1.3	• Know what is meant by freefall • Understand that all objects (in freefall) fall to the ground at the same acceleration due to gravity, g • Be able to use the equations for uniform acceleration for objects in freefall • Be able to determine the value of g using a freefall method
4.3.1	Projectile motion SPECIFICATION REFERENCE 3.4.1.4	• Understand that the vertical and horizontal motion of a projectile are independent of each other • Be able to use the equations of uniform acceleration to solve problems that include projectile motion • Be able to describe how air resistance can affect the trajectory of a projectile
4.3.2	Drag lift and terminal speed SPECIFICATION REFERENCE 3.4.1.4	• Know what is meant by friction and drag, and how they can oppose motion • Know that lift is an upwards force perpendicular to fluid flow • Know what is meant by terminal speed • Understand that an object moving through a fluid (a gas or liquid) will reach a terminal speed • Know that air resistance increases with speed • Know the effect of air resistance on the factors that affect the top speed of a vehicles
4.3.3	Conservation of momentum SPECIFICATION REFERENCE 3.4.1.6	• Know and be able to use the equation momentum = mass x velocity • Be able to use the principle of linear momentum to solve collision problems in one dimension • Understand that linear momentum is always conserved in a collision when no external forces act • Know that kinetic energy is conserved in elastic collisions but not in inelastic collisions or explosions
4.3.4	Force, momentum, and impulse SPECIFICATION REFERENCE 3.4.1.6	• Know that force us equal to the rate of change of momentum: $F = \frac{\Delta(mv)}{\Delta t}$ • Know that impulse is equal to the change in momentum and is given by $F\Delta t=\Delta(mv)$ where F is constant • Know that the area under a force-time graph is equal to impulse • Understand why momentum conservation issues are important in ethical transport design
4.3.5	Work and power SPECIFICATION REFERENCE 3.4.1.7	• Be able to calculate the work done by a force moving an object, using W=Fs or W=Fscosθ • Be able to calculate the rate of doing work (power) of something using $P=\Delta W/\Delta T$ = Fv • Know that the area under a force-displacement graph represents work done
4.3.6	Conservation of energy SPECIFICATION REFERENCE 3.4.1.7 AND 3.4.1.8	• Be able to recall the principle of conservation of energy • Be able to calculate efficiency as a decimal and a percentage • Efficiency = useful output/total input • Be able to calculate the kinetic energy of a moving object • Be able to calculate the change in gravitational potential energy of an object • Be able to solve conservation of energy problems involving kinetic energy and gravitational potential energy and spring energy and work one against resistive forces
	Required practical 3 – Finding g by freefall	

5. Materials

Nugget	Title	Content
5.1.1	Density SPECIFICATION REFERENCE 3.4.2.1	• Know what is meant by the density of a material • Be able to use the formula ρ=m/v to calculate the density, mass or volume of an object
5.1.2	Hooke's law SPECIFICATION REFERENCE 3.4.2.1	• Be able to recall Hooke's law • Be able to use the formula for Hooke's law, F=kΔL where k is stiffness/spring constant • Know what is meant by the elastic limit of a material • Know what is meant by plastic behaviour
5.1.3	Elastic potential energy SPECIFICATION REFERENCE 3.4.2.1	• Be able to calculate the elastic strain energy stored in a stretched material using the area under a force-extension graph or the formula: Energy stored = 1/2FΔL • Understand how energy is conserved in elastic stretches or when the material plastically deform • Know how energy is conserved in springs • Appreciate issues of energy conservation in transport design
5.1.4	Stress and strain SPECIFICATION 3.4.2.1	• Be able to define tensile stress and strain and breaking stress • Be able to interpret simple stress-strain curves and know how they differ from force-extension graphs • Breaking stress
5.1.5	Youngs modulus SPECIFICATION REFERENCE 3.4.2.2	• Be able to use the formula for the Young modulus • Be able to describe an experimental method used to determine the Young modulus • Be able to use stress-strain graphs to find the Young modulus
5.1.6	Brittle materials SPECIFICATION 3.4.2.1	• Describe and explain fracturing and brittle behaviour • Recognise fracturing and brittle behaviour on stress-strain and force-extension graphs
	Required practical 4 – Youngs modulus	

6. Electricity

Nugget	Title	Content
6.1.1	Circuit basics SPECIFICATION REFERENCE 3.5.1.1 AND 3.5.1.2	• Recognize and understand circuit symbols • Know the difference between conventional current and electron flow • Know how to draw circuit diagrams
6.1.2	Current, voltage and resistance in series SPECIFICATION REFERENCE 3.5.1.1 and 3.5.1.4	• Know that electric current is the rate of flow of charge • Understand and be able to use the equation: $I=\Delta Q/\Delta t$ • Know that potential difference is the work done per unit charge • Understand and be able to use: $V=W/Q$ • Knowing that resistance is defined by $R=V/I$ • Know that Ohm's law is a special case where $I \propto V$ under constant physical conditions • Understand how energy and charge are conserved in dc circuits • Know the relationships between currents, voltages and resistances in series • Be able to use $R_T=R_1+R_2+R_3+\ldots$ for resistors in series
6.1.3	Current, voltage and resistance in parallel SPECIFICATION REFERENCE 3.5.1.1 and 3.5.1.4	• Know the relationships between currents, voltages and resistances in parallel circuits • Be able to use $\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\cdots$ for resistors in parallel
6.1.4	Solving tricky circuit combinations	• Know how to solve more challenging circuits with both series and parallel sections
6.2.1	IV characteristics SPECIFICATION REFEENCE 3.5.1.2	• Understand the I-V graph for an ohmic conductor • Recognise and understand I-V curves for ohmic conductors, semiconductor diodes and filament lamps • I or V could be on the horizontal axis • Know what is meant by an ideal ammeter and an ideal voltmeter
6.2.2	Resistivity and superconductors SPECIFICATION REFERENCE 3.5.1.3	• Know that's the resistivity (ρ) of a material is defined as: $\rho=RA/L$ • Be able to describe the qualitative effect of temperature on the resistance of metal conductors and thermistors • Know applications of NTC thermistors (eg. Temperature sensors) and resistance-temperature graphs for thermistors • Know that superconductivity is a property of certain materials which have zero resistivity at and below a critical temperature which depends on the material • Know some applications of superconductors (eg. Very strong electromagnets and reduced energy loss in power cables)
6.2.3	Power and electrical energy SPECIFICATION REFERENCE 3.5.1.4 AND 3.5.1.4?	• Be able to find the power of a component using: $P=IV$, $P=I^2R$ or $P=V^2/R$ • Know how to find the energy transferred in a circuit: $E=IVt$
6.2.4	EMF and internal resistance SPECIFICATION REFERENCE 3.5.1.6	• Know what is meant by the internal resistance of a power source, r • Know what is meant by the electromotive force (EMF), ε • Know what is meant by the terminal p.d • Be able to use $\varepsilon=E/Q$ and $\varepsilon=I(R+r)$ • Be able to investigate the EMF and internal resistance of electric cells and batteries by measuring the variation of terminal p.d against current • Know the relationships between cells in series and identical cells in parallel
6.2.5	Potential dividers SPECIFICATION REFERENCE 3.5.1.5	• Understand how a potential divider can be used to supply constant or variable potential difference from a power supply • Know examples of the use of variable resistors, thermistors and light dependent resistors (LDR's) in a potential divider
	Required practical 5 – Resistivity	
	Required practical 6 – EMF and internal resistance	

7. Further mechanics

Nugget	Title	Content
7.1.1	Radians SPECIFICATION REFERENCE 3.6.1.1	• Know how to use radians as a measure of angle
7.1.2	Angular speed SPECIFICATION REFERENCE 3.6.1.1	• Know that angular speed, ω, is the angle an object rotates through in one second • Be able to calculate the angular speed using ω=v/r • Know how to calculate angular speed using ω=2πf
7.1.3	Centripetal acceleration SPECIFICATION REFERENCE 3.6.1.1	• Understand that an object travelling in a circle is accelerating towards the centre of the circle • Understand that centripetal acceleration is due to a centripetal force • Know how to use the equations for centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$
7.1.4	Centripetal force SPECIFICATION REFERENCE 3.6.1.1	• Know how to use the equations for centripetal force $a = \frac{v^2}{r} = \omega^2 r$ and $F = \frac{mv^2}{r} = m\omega^2 r$
7.1.5	Motion in a vertical circle SPECIFICATION REFERENCE 3.6.1.1	• Know how to apply equations for centripetal force in examples where motion is in a vertical circle
7.1.6	Circular motion at an angle SPECIFICATION REFERENCE 3.6.1.1	• Know how to apply equations for centripetal force in examples where motion is at an angle
7.2.1	Simple harmonic motion intro SPECIFICATION REFERENCE 3.6.1.2 and 3.6.1.3	• Know the characteristics of simple harmonic motion (SHM) • The condition for SHM is: a α –x • Be able to sketch the graphs of displacement, velocity and acceleration for an object moving with SHM as a function of time, and understand the phase difference between them • Know that velocity is given by the gradient of a displacement-time graph, and that acceleration is the gradient of a velocity-time graph
7.2.2	Calculations with SHM SPECIFICATION REFERENCE 3.6.1.2	• Know that the displacement of an object moving with SHM is given by x=Acos(ωt) • Know that the defining equation of SHM is $a=-\omega^2 x$ • Know that the magnitude of the maximum acceleration of an object moving with SHM is: $a_{max}=\omega^2 A$ • Know that the velocity of an object moving with SHM is given by: $v = \pm\omega\sqrt{(A^2 - x^2)}$ • Know that the maximum speed of an object moving with SHM is given by $v_{max}=\omega A$
7.2.3	Energy of oscillators SPECIFICATION REFERENCE 3.6.1.2 and 3.6.1.3	• Be able to describe how kinetic, potential and mechanical energy change with displacement for an object moving with SHM and also how kinetic and potential energy change with time
7.2.4	Simple harmonic oscillators SPECIFICATION REFERENCE 3.6.1.3	• Know that a mass on a spring is a simple harmonic oscillator • Know the formula for the period of a mass-spring system $T = 2\pi\sqrt{\frac{m}{k}}$ • Know how to verify how the period of oscillation for a mass on a spring depends on mass, spring constant and amplitude using an experiment (required practical 7)
7.2.5	Free and forced vibrations SPECIFICATION REFERENCE 3.6.1.3 and 3.6.1.4	• Understand what is meant by free and forced vibrations • Know how the phase difference between the driver and the oscillator changes with increasing driving frequency • Know what resonance is, and that it occurs when the driving frequency approaches the natural frequency
7.2.6	Damping SPECIFICATION REFERENCE 3.6.1.3 and 3.6.1.4	• Know what damping is and the effect it has on oscillations • Understand the effects of different levels on the sharpness of resonance • Be able to give examples of damping in mechanical systems, including those involving stationary wave
	Required practical 7A – Simple pendulum	
	Required practical 7B – Mass spring system	

8. Thermal physics

Nugget	Title	Content
8.1.1	Specific heat capacity SPECIFICATION REFERENCE 3.6.2.1 and 3.6.2.2	• Be able to calculate the change in temperature using Q=mcΔθ • Be able to do calculations involving continuous flow • Understand that during a change of state the potential energies of the particles are changing but not the kinetic energies • Be able to do calculations involving transfer of energy
8.1.2	Specific latent heat SPECIFICATION REFERENCE 3.6.2.1 and 3.6.2.2	• Know that Q=ml for a change of state
8.1.3	Tricky thermal transfer problems SPECIFICATION REFERENCE 3.6.2.1 and 3.6.2.2	• Understand how to solve more challenging energy transfer problems
8.2.1	Absolute zero and kelvin temperature scale SPECIFICATION REFERENCE 3.6.2.1 and 3.6.2.2	• Know that there is an 'absolute zero' of temperature, given as 0 K or -273°C
8.2.2	Pressure law SPECIFICATION REFERENCE 3.6.2.2 and 3.6.2.3	• Understand the absolute temperature scale • Know that the pressure law is an experimental relationship between p, V and T and mass • Be able to explain the relationships between p, V and T in terms of a simple molecular model
8.2.3	Boyles law SPECIFICATION REFERENCE 3.6.2.2 and 3.6.2.3	• Know that the Boyle's law is an experimental relationship between p, V and T and mass • Be able to explain the relationships between p, V and T in terms of a simple molecular model • Be able to investigate Boyle's law experimentally (required practical 8)
8.2.4	Charles' law SPECIFICATION REFERENCE 3.6.2.2 and 3.6.2.3	• Know that the Charles' law is an experimental relationship between p, V and T and mass • Be able to explain the relationships between p, V and T in terms of a simple molecular model • Be able to investigate Charles' law experimentally (required practical 8)
8.2.5	Molar mass an Avogadro's constant SPECIFICATION 3.6.2.2	• Know what is meant by molecular mass and molar mass • Know what the Avogadro constant, NA, the molar gas constant, R, and the Boltzmann constant, k, are
8.2.6	The ideal gas equation SPECIFICATION 3.6.2.2	• Be able to use the ideal gas equation pV=nRT for n moles • Be able to use the ideal gas equation pV=NkT for N molecules
8.2.7	Work done on a gas SPECIFICATION 3.6.2.2	• Know that work done on a gas of constant pressure as it changes volume is given by pΔV
8.3.1	Intro to kinetic theory SPECIFICATION REFERENCE 3.6.2.3	• Understand that the gas laws are empirical and the kinetic theory model is theoretical • Know how knowledge and understanding of the behaviour of gases has changed over time • Know what Brownian motion is and how it provides evidence for the existence of atoms
8.3.2	Deriving the kinetic theory equation SPECIFICATION REFERENCE 3.6.2.3	• Know how the formula pV=$\frac{1}{3}Nm(c_{rms})^2$ is derived for an ideal gas using algebra and conservation of momentum • Be able to explain the relationships between p, V and T in terms of a simple molecular model • Know the assumptions made about an ideal gas in kinetic theory
8.3.3	Using the kinetic theory equation SPECIFICATION REFERENCE 3.6.2.3	• Know hot to use the kinetic theory equations
8.3.4	Calculating the energy of a gas SPECIFICATION REFERENCE 3.6.2.3	• Know that the internal energy of a body is the sum of the randomly distributed kinetic and potential energies of its particles • Know how the internal energy of a system is increased when energy is transferred to it (and vice versa) • Understand that for an ideal gas the internal energy is just the kinetic energy of the atoms • Know that the average molecular kinetic energy of a gas is given by $\frac{1}{2}m(c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$
	Required practical 8A – Boyles law	
	Required practical 8B – Charles law	

9. Gravitational and electric fields

Nugget	Title	Content
9.1.1	Intro to gravitational fields SPECIFICATION REFERENCE 3.7.1, 3.7.2.1 and 3.7.2.2	• Concept of a force field as a region in which a body experiences a non-contact force • Know that force fields are present in the interaction between masses and static or moving charges • Understand that gravity acts as an attractive force between all matter • Know that force fields can be represented as vectors, the direction of which must be determined by inspection • Be able to represent gravitational fields with gravitational field lines • Know that the gravitational law is an inverse square law
9.1.2	Gravitational force SPECIFICATION REFERENCE 3.7.1, 3.7.2.1 and 3.7.2.2	• Know how to calculate the magnitude of the force due to gravity between two point masses using Newton's law of gravitation F=(Gm_1 m_2)/r^2 • Know that G is the gravitational constant
9.1.3	Gravitational fields strength SPECIFICATION REFERENCE 3.7.2.2 and 3.7.2.3	• Know that gravitational field strength is denoted by, g, and defined as the force per unit of mass g=F/m • Be able to calculate the gravitational field strength, including in a radial field g=GM/r^2 • Be able to sketch the graph of g against r
9.1.4	Gravitational potential part 1 SPECIFICATION REFERENCE 3.7.2.3	• Know what is meant by gravitational potential, including why it is zero at infinity • Be able to calculate gravitational potential using the equation V=-GM/r and understand the significance of the negative sign • Be able to sketch the graph of V against r in a radial gravitational field • Be able to calculate the value of g at a given point using the gradient of a graph of V against r and the equation g=-ΔV/Vr • Know and use the fact that ΔV can be found from the area under the graph of g against r
9.1.5	Gravitational potential part 2 SPECIFICATION REFERENCE 3.7.2.3	• Know what gravitational potential difference is • Know that the work done to move a mass is given by ΔW=mΔV • Understand what equipotential surfaces are • Know that no work is done when moving along an equipotential surface
9.1.6	Satellite orbits SPECIFICATION REFERENCE 3.7.2.4	• Know what a synchronous orbit is • Know what geostationary and low orbiting satellites are, including their planes or orbit and radii
9.1.7	Orbital equations SPECIFICATION REFERENCE 3.7.2.4	• Understand how the speed and orbital period of a satellite are affected by the radius of its orbit • Know the derivation of T2 α r3 (keplers 3rd law) • Understand the relationship between the kinetic energy and gravitational potential energy of a satellite • Know that the total energy of a satellite is its kinetic energy plus its gravitational potential energy and is always constant • Understand what escape velocity is
9.2.1	Intro to electric fields SPECIFICATION REFERENCE 3.7.3.1, 3.7.3.2 and 3.7.3.3	• Know how to represent an electric field using field lines
9.2.2	Electric force SPECIFICATION REFERENCE 3.7.3.1, 3.7.3.2 and 3.7.3.3	• Know that the force between two point charges in a vacuum is $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}$, where ε_0 is the permittivity of free space • Understand that air can be treated as a vacuum when using Coulomb's law
9.2.3	Electric field strength SPECIFICATION REFERENCE 3.7.3.1, 3.7.3.2 and 3.7.3.3	• Know that electric field strength is defined as the force per unit charge and can be calculated using E=F/Q • Be able to find the electric field strength of radial and uniform fields using E= $\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$ and E=V/d • Know that a charged sphere can be treated as a point charge at the centre of the sphere • Know how to sketch graphs of E against r
9.2.4	Charged particles fired into a uniform field SPECIFICATION REFERENCE 3.7.3.1, 3.7.3.2 and 3.7.3.3	• Understand the trajectory of a moving charged particle in a uniform electric fields
9.2.5	Electric potential part 1 SPECIFICATION REFERENCE 3.7.3.2 and 3.7.3.3	• Understand the definition of absolute electric potential, including its value of zero at infinity • Be able to calculate the electric potential of a charged object in a radial electric field using $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$ • Be able to sketch graphs of V against r for positive and negative point charges, and know that the gradient of these graphs gives the electric field at a point r, where E=$\frac{\Delta V}{\Delta r}$
9.2.6	Electric potential part 2 SPECIFICATION REFERENCE 3.7.3.2 and 3.7.3.3	• Understand the definition of electric potential difference • Know that ΔV can be found from the area under a E-r graph • Be able to calculate the work done in moving a charged object through an electric potential difference using ΔW=mΔV • Be able to derive the work done in moving a charge between plates form Fd=QΔV • Know what equipotential surfaces are, and understand that no work is done on a charge moving along an equipotential surface
9.2.7	Comparing electric and gravitational fields SPECIFICATION REFERENCE 3.7.1	• Know and understand the similarities and differences between gravitational and electrostatic forces • Similarities: Both have inverse-square force laws that have many characteristics in common, eg use of field lines, use of potential concept, equipotential surfaces etc • Differences: masses always attract, but charges may attract or repel • Be able to compare the magnitude of the gravitational and electrostatic forces between subatomic particles

10. Capacitors

Nugget	Title	Content
10.1.1	Capacitors SPECIFICATION REFERENCE 3.7.4.1	• Know the definition of capacitance • Know that capacitance, C=Q/V • Know what a capacitor is and how it stores charge
10.1.2	Energy stored by capacitors SPECIFICATION REFERENCE 3.7.4.3	• Know how to calculate the energy stored in a capacitor using E=1/2QV, E=1/2CV2, E=1/2(Q2/V) • Know that the area under the graph of charge against p.d. is the energy stored by a capacitor
10.1.3	Dielectrics SPECIFICATION REFERENCE 3.7.4.2	• Understand the terms relative permittivity and dielectric constant • Be able to describe the action of a simple polar molecule that rotates in the presence of an electric field • Know that the capacitance of a capacitor can be found using C=(Aε_0 ε_r)/d
10.1.4	Charging and discharging SPECIFICATION REFERENCE 3.7.4.4	• Be able to represent the charging and discharging of capacitors through resistors graphically for Q, V and I against time • Be able to interpret the gradients of and areas under these graphs where appropriate • Know that the charge on a charging capacitor is given by $Q = Q_0(1 - e^{-\frac{t}{RC}})$ • Know that the charge, potential difference and current for a discharging capacitor are given by: • $Q = Q_0(e^{-\frac{t}{RC}}), V = V_0\left(e^{-\frac{t}{RC}}\right), I = I_0(e^{-\frac{t}{RC}})$ • Be able to investigate the charge and discharge of capacitors and analyse the results by plotting a log-linear graph (require practical 9)
10.1.5	Time constant and time to halve SPECIFICATION REFERENCE 3.7.4.4	• Know what the time constant of a charging or discharging capacitor is, and that it is given by τ=RC • Be able to calculate the time constant of a charging or discharging capacitor, including from graphical data • Be able to calculate the time to halve knowing that $T_{1/2}$=0.69RC
	Required practical 9A – Discharging a capacitor	
	Required practical 9B – Charging a capacitor	

11. Magnetic fields

Nugget	Title	Content
11.1.1	Magnetic flux density SPECIFICATION REFERENCE 3.7.5.1	• Know that a force can act on a current-carrying wire in a magnetic field • Know Fleming's left hand rule • Know what is meant by magnetic flux density, B, and know it's measured in teslas • Know the definition of the tesla • Be able to use F=BIL to find the force on a current-carrying wire when the field is perpendicular to current • Be able to investigate how the force on a wire varies with current, flux density and length of wire using a top pan balance (require practical 10)
11.1.2	Forces on charged particles SPECIFICATION REFERENCE 3.7.5.2	• Understand that a charged particle moving through a magnetic field experiences a force • Be able to calculate the force acting on a charged particle whose velocity is perpendicular to a uniform magnetic field with F=BQv • Know how to work out the direction a force will act in for positive and negatively charged particles • Know that a charged particle follows a circular path in a magnetic field perpendicular to its velocity • Know how the circular path of charged particles can be applied in devices such as the cyclotron
11.1.3	Electromagnetic induction SPECIFICATION REFERENCE 3.7.5.3	• Know that magnetic flux is given by ϕ=BA, where B is normal to A • Understand that the magnetic flux linkage is Nϕ, where N is the number of turns in a coil cutting the flux • Be able to calculate the magnetic flux linkage of a rectangular coil rotated in a magnetic field, eg. Using Nϕ=BANcosθ • Know how to investigate, using a search coil and an oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction (required practical 11)
11.1.4	Faraday's law and Lenz's law SPECIFICATION REFERENCE 3.7.5.4	• Know faraday's law • Know the magnitude of an induced emf is equal to the rate of change of flux linkage, given by $\varepsilon = N\frac{\Delta\emptyset}{\Delta t}$ • Know Lenz's law • Be able to apply faraday's law and Lenz's law e.g. to a straight conductor moving in a magnetic field • Be able to calculate the emf induced in a coil rotating uniformly in a magnetic field using ε=BANωsinωt
11.1.5	Alternating current SPECIFICATION REFERENCE 3.7.5.5	• Be familiar with the operation of the controls of an oscilloscope • Know how an oscilloscope can be used as a dc and ac voltmeter, and how to use it to measure time intervals and frequencies, and to display ac waveforms • Know how to calculate the peak, peak-to-peak and rms values for sinusoidal voltages and currents • Be able to use $V_{rms}=V_0/\sqrt{2}$ and $I_{rms}=I_0/\sqrt{2}$ • Be able to calculate the mains electricity peak voltage and peak-to-peak voltage values
11.1.6	Transformers SPECIFICATION REFERENCES 3.7.5.6	• Be able to use the equation for an ideal transformer, $\frac{N_s}{N_p} = \frac{V_s}{V_p}$ to find the number of turns or voltage on either coil • Know what can cause inefficiencies in a transformer • Know how eddy currents can be produced • Be able to calculate the efficiency of a transformer using efficiency = $\frac{I_s V_s}{I_p V_p}$ • Know how and why electrical power is transmitted at high voltage and be able to do calculations of power loss in transmission lines
	Required practical 10 – Force on a current carrying wire	
	Required practical 11 – Investigation using a search coil	

12. Nuclear physics

Nugget	Title	Content
12.1.1	Measuring nuclear radius SPECIFICATION REFERENCE 3.8.1.1 AND REFERENCE 3.8.1.5	• Understand how Rutherford scattering of alpha particles demonstrates the existence of the atomic nucleus • Appreciate how the knowledge and understanding of the structure of the nucleus has changed over time • Estimate the radius of a nucleus by calculating the distance of closest approach of an alpha particle using Coulomb's law • Be able to determine the radius of a nucleus using electron diffraction • Be familiar with the graph of intensity against angle for electron diffraction by a nucleus
12.1.2	Nuclear density SPECIFICATION REFERENCE 3.8.1.5	• Know that the radius of an atomic nucleus is typically around 1fm (=1015m) • Know that nuclear radius increases with increasing nucleon number • Know that R=R0A1/3, where R is the radius of a nucleus, A is the nucleon number and R0 is a constant • Know that R=R0A1/3 is derived from experimental data, and that it provided evidence that nuclear materials have a constant density • Be able to calculate nuclear density
12.1.3	Properties of nuclear radiation SPECIFICATION REFERENCE 3.8.1.2	• Know the properties of each type of radiation • Know how to identify alpha, beta and gamma radiation using simple absorption experiments • Know some application of each type of nuclear radiation, including how radiation can be used to measure the thickness of paper, aluminium foil and steel • Know the relative hazards of exposure to humans of each type of nuclear radiation • Appreciate the balance between the risks and benefits in the use of radiation in medicine
12.1.4	Background radiation and intensity SPECIFICATION REFERENCE 3.8.1.2	• Know examples of the origins of background radiation • Be able to accurately eliminate background radiation from experiment results • Know that the intensity of gamma radiation decreases with distance from a source according to the inverse square law, $I=k/x^2$ • Be able to investigate and experimentally verify the inverse square law for gamma radiation (RP 12) • Know how the inverse square law can be applied to the safe handling of radioactive sources
12.2.1	Exponential law of decay SPECIFICATION REFERENCE 3.8.1.2	• Know that radioactive decay is random and that a given nucleus has a constant probability of decay • Know and be able to use the term activity, A, given by A=λN, where N is the number of unstable nuclei and λ is the decay constant • Be able to use the equation for the rate of change of N: $\frac{\Delta N}{\Delta t} = -\lambda N$ • Be able to model the rate of change of N, eg. Using spreadsheet modelling • Understand that N varies exponentially with time: $N=N_0e^{-\lambda t}$ • Be able to answer questions on radioactive decay involving molar mass or the Avogadro constant • Understand that A varies exponentially with time: $A=A_0e^{-\lambda t}$
12.2.2	Half-life and its applications SPECIFICATION REFERENCE 3.8.1.3	• Be able to use the half-life equation: $T_{1/2}=\frac{ln2}{\lambda}$ • Be able to find half-life from decay curves and log graphs • Understand how the half-life of an isotope is relevant to its applications, eg. Storage of radioactive waste, radioactive dating
12.2.3	Nuclear decay SPECIFICATION REFERENCE 3.8.1.4	• Be able to sketch the graph of N (number of neutrons) against Z (proton number) for stable nuclei, and identify regions of particles that will undergo α and β decay • Know the possible decay modes of unstable nuclei, including: α, β^-, β^+ and electron capture • Know how N and Z are changed by radioactive decay, and be able to represent these decays using simple decay equations • Know that γ-rays can be emitted by nuclei in excited states and its applications, eg. Technetium-99m as a gamma source in medical diagnosis • Understand and be able to use nuclear energy level diagrams
12.3.1	Mass defect and binding energy SPECIFICATION REFERENCE 3.8.1.6	• Appreciate that $E=mc^2$ applies to all energy changes • Know that a mass defect of 1 u (where u is an atomic mass unit) is equivalent to a binding energy of 931.5MeV • Be able to do simple calculations involving mass difference and binding energy • Be able to sketch the graph of binding energy per nucleon against nucleon number
12.3.2	Nuclear fission and fusion SPECIFICATION REFERENCE 3.8.1.6	• Know that nuclear fission is the splitting of larger nuclei into smaller nuclei • Know that nuclear fusion is the combining of two smaller nuclei into one larger nucleus • Know that energy can be released during fission or fusion due to an increase in binding energy per nucleon • Identify, on a plot of average binding energy per nucleon against nucleon number, the regions where nuclei will release energy when undergoing fission/fusion • Be able to calculate the energy released during fission or fusion from nuclear masses
12.3.3	Nuclear fission reactors SPECIFICATION REFERECNE 3.8.1.6, 3.8.1.7 AND 3.8.1.8	• Know that thermal neutrons can induce fission in uranium nuclei and start a fission chain reaction • Understand the term critical mass • Know functions of the moderator, control rods and coolant in a thermal nuclear reactor, be able to give examples of materials used for these functions and explain why certain materials are chosen for these • **Know a simple mechanical model of moderation by elastic collisions** • **Know examples of fuel used and production of them** • Know ways in which the risks of nuclear power are minimised, eg. Remote handling of fuel, shielding, emergency shut down mechanisms • Know why fission waste products are dangerous, and how they are handled and stored • Appreciate the balance between the benefits and risks of nuclear power, and that scientific knowledge of nuclear energy allows society to make informed decisions
	Required practical 12 – Investigate the inverse square law using a gamma source	

13. Astrophysics

Nugget	Title	Content
13.1.1	Lenses SPECIFICATION REFERENCE 3.9.1.1	• What the principle focus, focal point and focal plane are for a converging lens • How to draw ray diagrams to show an image being formed by a converging lens • That images can be real or virtual • The lens equations 1/f = 1/u + 1/v and how to use it
13.1.2	Optical telescopes SPECIFICATION REFERENCE 3.9.1.1, 3.9.1.2 and 3.9.1.4	• Be able to draw a ray diagram of an astronomical refracting telescope forming an image in normal adjustment • Be able to define f_o and f_e for an astronomical refracting telescope and know that f_o>>f_e • Be able to calculate the magnification of an astronomical refracting telescope using M=(angle subtended by image at eye)/(angle subtended by object at unaided eye) or M=f_o/f_e • Know the Cassegrain arrangement for a reflecting telescope and be able to draw a ray diagram showing the path of rays through the telescope up to the eyepiece • Be able to compare the eye and CCDs as detectors in terms of quantum efficiency, resolution, and convenience of use
13.1.3	Comparing telescopes SPECIFICATION REFERENCE 3.9.1.2 and 3.9.1.4	• Understand what the minimum angular resolution of a telescope is and be able to calculate it using the Rayleigh criterion: $\theta \approx \frac{\lambda}{D}$ • Know that the radian is a unit of angle • Know the relative merits of using reflecting and refracting telescopes, including the problems of spherical and chromatic aberration
13.1.4	Non-optical telescopes SPECIFICATION REFERENCE 3.9.1.3 and 3.9.1.4	• Understand how the following telescopes work: single-dish radio telescopes, IR telescopes, UV telescopes and X-ray telescopes • Understand the similarities and differences between optical telescopes and the telescopes listed above – to include the structure, where they should be positioned, and how they are used • Know that the collecting power of a telescope is proportional to the square of the diameter of the mirror or dish • Be able to compare the resolving powers and collecting power of optical, single dish radio, IR, UV and x-ray telescopes
13.1.5	Parallax and parsecs SPECIFICATION REFERENCE 3.9.2.2	• Understand parsecs and light years as distance measurements
13.2.1	Magnitude SPECIFICATION REFERENCE 3.9.2.1, 3.9.2.2 and 3.9.2.6	• Understand how stars can be classified by their luminosity (or power output) • Know that brightness is a subjective scale of measurement • Know what is meant by apparent magnitude, m, and that it' measured with a scale invented by Hipparcos, where the dimmest visible stars have an apparent magnitude of 6 • Know the relationship between brightness and *m* • Know what is meant by absolute magnitude, M • Relation between brightness and apparent magnitude. Difference of 1 on magnitude scale is equivalent to an intensity ration of 2.51 • Understand how M and m are related by the formula: $m-M=5\log\frac{d}{10}$ • Understand how type 1a supernovae can be used as standard candles to determine distances
13.2.2	Stars as blackbodies SPECIFICATION REFERNCE 3.9.2.3	• Understand what is meant by a black body • Know the general shape of black body radiation curves • Know that it can be assumed that a star is a blackbody • Understand Wien's displacement law: $\lambda_{max}T=2.9\times10^{-3}$mK and be able to use it to estimate the black-body temperature of a source • Understand Stefan's law: $P=\sigma AT^4$ and be able to use it to compare the power output, temperature and size of stars • Know and understand how to use the inverse square law for intensity: $I=\frac{P}{4\pi d^2}$ • Know what assumptions are made when applying the inverse square law
13.2.3	Stellar spectral classes SPECIFICATION REFERENCE 3.9.2.4	• Know that hydrogen Balmer absorption lines are caused by the excitation of electrons in the n=2 energy level • Understand how astronomers can use Hydrogen Balmer lines to determine stellar temperature • Know how stars can be classified according to their spectra • Know the seven spectral classes used to classify stars O, B, A, F, G, K M • Be able to classify stars into one of the seven spectral classes from their colour, temperature, or prominent absorption lines
13.2.4	Hertzsprung-Russell diagram SPECIFICATION REFERENCE 3.9.2.5	• Know the general shape of the Hertzsprung-Russel diagram, including the position of the main sequence, dwarf and giant stars • Know that the absolute magnitude axis on an HR-diagram ranges from -10 to +15 • Know that the x-axis on an HR-diagram either shows temperature ranging from 50,000K to 2500K, or the spectral classes OBAFGKM •
13.2.5	Evolution of sun like stars SPECIFICATION REFERENCE 3.9.2.5	• Be familiar with the position of our Sun on an H-R diagram • Understand the stellar evolution of a sun-like star from formation to white dwarf • Understand how a sun-like star moves around the H-R diagram as it evolves
13.3.1	Supernovae and Neutron stars SPECIFICATION REFERENCE 3.9.2.6	• Know the defining properties of supernova, including a rapid increase in absolute magnitude • Know that a burst of gamma rays can be emitted when a massive star collapses • Be able to compare the energy output of a supernova to that of the Sun • Be able to recognise the light curve for a type 1a supernova, and know how this relates to a type 1a supernova's use as a standard candle • Understand how neutron stars and black holes are formed • Know the composition and density of a neutron star •
13.3.2	Black holes and quasars SPECIFICATION REFERENCE 3.9.2.6	• Know that a black hole is an object that has an escape velocity greater than the speed of light, c • Know that astronomers believe that there is a supermassive black hole at the centre of every galaxy • Know that the radius of the event horizon of a black hole is called the Schwarzschild radius (R_s), and be able to calculate it using $R_s=\frac{2GM}{c^2}$ • Know that quasars are bright radio sources and this is how they were discovered and are the most distant objects that we can measure • Know that quasars show large optical red shifts, indicating that they are very far away • Be able to estimate the distance and power output of quasars • Know that quasars are thought to form around supermassive black holes
13.3.3	The doppler effect and red shift SPECIFICATION REFERENCE 3.9.3.1 and 3.9.3.2	• Understand the Doppler effect • Understand and be able to apply the formulas for red shift: $z=\frac{\Delta f}{f}=\frac{v}{c}$ and $\frac{\Delta\lambda}{\lambda}=-\frac{v}{c}$ for v<<c applied to optical and radio frequencies
13.3.4	The big bang theory SPEPCIFICATION REFERENCE 3.9.2.6 and 3.9.3.2	• Know that Hubble's law, v=Hd, provides a simple interpretation of the expansion of the universe • Understand the Big Bang theory as the current consensus for the origin of the universe • Be able to estimate the age of the universe, assuming H is constant • Understand the evidence for the Big Bang theory, including the red shift of distant galaxies, CMBR and the relative abundance of H and He Understand that dark energy is a possible explanation for an expanding universe, but that this is a controversial theory
13.3.5	Detection of binary stars and exoplanets SPECIFICATION REFERENCE 3.9.3.1, 3.9.3.3 and 3.9.3.4	• Be able to apply the Doppler effect to binary stars • Know what exoplanets are and why they are hard to detect • Know that Doppler shift and the transit method can be used to detect exoplanets • Recognise the typical light curve for an exoplanet in transit across a star