

PHYSICS SL/HL

Higher level students will study certain topics in more detail. The details are listed in the *Additional higher level content shown in italics*.

Measurements and uncertainties: Measurements in physics, Uncertainties and errors, Vectors and scalars.

Mechanics: Motion, Forces, Work, Energy and power, Momentum and impulse.

Thermal physics: Thermal concepts, Modelling a gas.

Waves: Oscillations, Travelling waves, Wave characteristics, Wave behaviour, Standing waves.
Simple harmonic motion, Single-slit diffraction, Interference, Resolution, Doppler effect.

Electricity and magnetism: Electric fields, Heating effect of electric currents, Electric cells, Magnetic effects of electric currents

Circular motion and gravitation: Circular motion, Newton's law of gravitation

Describing fields, Fields at work

Atomic, nuclear and particle physics: Discrete energy and radioactivity, Nuclear reactions, The structure of matter

The interaction of matter with radiation, Nuclear physics

Energy production: Energy sources, Thermal energy transfer

Electromagnetic induction, Power generation and transmission, Capacitance

Options

One of the following options will be covered depending on student's interest:

Relativity: The beginnings of relativity, Lorentz transformations, Space-time diagrams

Relativistic mechanics, General relativity

Engineering physics: Rigid bodies and rotational dynamics, Thermodynamics

Fluids and fluid dynamics, Forced vibrations and resonance

Astrophysics: Stellar quantities, Stellar characteristics and stellar evolution, Cosmology

Stellar processes, Further cosmology.

Assessment

Students will be tested on their understanding and use of scientific concepts, and their experimental skills. The course assessment is based on student performance in homework, practical work, end of unit tests, and mid- and end of year exams. Formative assessment includes peer assessment.

The final assessment is based on one Internal Assessment component and three external components:

Paper 1 (SL: 20 % of final grade, HL: 20 %): Multiple choice questions in the order of the syllabus	Internal assessment (SL and HL: 20 %): An in-depth 12 page individual practical or literature-based individual investigation.
Paper 2 (SL: 40% HL: 36 %): Short-answer and extended-response questions on core material (SL/HL) <i>and Advanced Higher Level Material</i> (HL only).	Paper 3 (SL: 20% HL: 24 %): Section A: one data-based question and several short-answer questions on experimental work. Section B: short-answer and extended-response questions on the Relativity or Engineering option studied.

Year 1: Sept – Dec (12 weeks)	
Content	Connections, Resources, Assessment
<p>Mechanics Introduction: Course overview. Distance and displacement, speed and velocity, acceleration, graphs describing motion, equations of motion for uniform acceleration, projectile motion, fluid resistance and terminal speed, objects as point particles, free-body diagrams, translational equilibrium, Newton’s laws of motion, solid friction kinetic energy, gravitational potential energy, elastic potential energy, work done as energy transfer, power as rate of energy transfer, principle of conservation of energy, efficiency Newton’s second law expressed in terms of rate of change of momentum Impulse and force – time graphs Conservation of linear momentum Elastic collisions, inelastic collisions and explosions Measurements and uncertainties: Random and systematic errors, absolute, fractional and percentage uncertainties. Vectors Vector and scalar quantities, combination and resolution of vectors</p>	<p>Possible experiments include Determination of g from analysing a video Determination of g from a pendulum Investigating projectile motion Investigating motion through a fluid using video capture Logger Pro data analysis exercise: error bars on graphs Investigating impact craters Investigating a bouncing ball TOK <ul style="list-style-type: none"> • Classical physics believed that the whole of the future of the universe could be predicted from knowledge of the present state. To what extent can knowledge of the present give us knowledge of the future? • The independence of horizontal and vertical motion in projectile motion is counter-intuitive. How does our intuition help and hinder the pursuit of knowledge? • What is the nature of certainty and proof in mathematics? Can scientific knowledge be justified in the same way? • To what extent is scientific knowledge based on fundamental concepts such as energy? What happens to scientific knowledge when our understanding of such fundamental concepts changes or evolves? Links There are opportunities for linking with Functions and Geometry and trigonometry in Mathematics.</p>
<p>Thermal Physics Molecular theory of solids, liquids and gases, Temperature and absolute temperature, internal energy, Specific heat capacity, phase change specific latent heat, pressure, equation of state for an ideal gas, kinetic model of an ideal gas, Mole, molar mass and the Avogadro constant, differences between real and ideal gases</p>	<p>Possible experiments include Verification of gas laws; Determination of the Avogadro constant Virtual investigation of gas law not possible within a school laboratory setting Measure specific latent heat of vaporization of water Measure specific latent heat of fusion of water Measure specific heat capacity of water TOK: <ul style="list-style-type: none"> • Activity: <i>What’s in the box? Distinction between a model and reality.</i> When does a model become "good enough" to count as knowledge of reality? CAS: Discussion of heat conservation issues and ethical responsibilities of energy conservation. The Koh-Ed group organises activities such as making gas-thermometers with simple materials enabling them to find a value for absolute 0. Links: There are opportunities for linking with Stoichiometric Relations, Energetics and Chemical Kinetics in Chemistry. Thermal properties of water in Molecular Biology, and Energy and Equilibrium in Environmental Systems and Societies.</p>
<p>Mock paper 1 and paper 2 exams on material covered to date.</p>	<p>Revision lists will be provided to supplement class notes.</p>

Year 1: Jan – March (10 weeks)	
Content	Connections, Resources, Assessment
<p>Waves and Wave Phenomena Simple harmonic oscillations, Time period, frequency, amplitude, displacement and phase difference, Conditions for simple harmonic motion, Travelling waves, Wavelength, frequency, period and wave speed, Transverse and longitudinal waves The nature of electromagnetic waves, The nature of sound waves, Wave fronts and rays, Superposition Polarization, Reflection and refraction, Snell's law, critical angle and total internal reflection Diffraction through a single-slit and around objects Interference patterns, Double-slit interference Path difference, The nature of standing waves, Boundary conditions, Nodes and antinodes</p>	<p>Possible experiments include Speed of waves in different media; Use of echo methods [or similar] for determining wave speed, wavelength, distance, or medium elasticity and/or density. Observation of polarization under different conditions, Determination of refractive index and application of Snell's law. Examination of diffraction patterns through apertures and around obstacles; investigation of the double-slit experiment. TOK:</p> <ul style="list-style-type: none"> The harmonic oscillator is a paradigm for modelling where a simple equation is used to describe a complex phenomenon. How does such an effective model affect the perspective of how scientists approach new problems? To what extent has the wave model of reality helped or hindered the development of knowledge in the sciences? <p>Links: There are opportunities for linking with Geometry and trigonometry in Mathematics.</p>
<p>Additional Higher Level <i>The defining equation of SHM, Energy changes, The nature of single-slit diffraction, Young's double-slit experiment, Modulation of two-slit interference pattern by one-slit diffraction effect, Multiple slit and diffraction grating interference patterns, Thin film interference, The size of a diffracting aperture The resolution of simple monochromatic two-source systems, The Doppler effect for sound waves and light waves.</i></p>	<p>Possible experiments include Investigating the Doppler effect/Train speed using Doppler Effect. Investigation of simple or torsional pendulums. Analysis of spectral data and images of receding galaxies available from professional astronomical observatories. SHM Damping data gathering and analysis Links: There are opportunities for linking with Geometry and trigonometry in Mathematics.</p>
<p>Circular Motion and Gravitation and Fields Period, frequency, angular displacement and angular velocity, Centripetal force, Centripetal acceleration Newton's law of gravitation,</p>	<p>Possible activities include: Investigations of mass on a string in circular motion Kepler's third law using NASAJ-SAT website database TOK:</p> <ul style="list-style-type: none"> Foucault's pendulum gives a direct observable evidence of the earth's rotation. Which ways of knowing do we use to interpret indirect evidence? <p>Links:</p> <ul style="list-style-type: none"> There are opportunities for linking with Geometry and trigonometry in Mathematics.
<p>Additional Higher Level <i>Gravitational fields, gravitational potential, Field lines, Equipotential surfaces, Potential and potential energy, Potential gradient, Escape speed, Orbital motion, orbital speed and orbital energy</i></p>	<p>TOK:</p> <ul style="list-style-type: none"> Were gravitational fields discovered or invented? <p>Links: There are opportunities for linking with Geometry and trigonometry in Mathematics</p>
<p>Mock paper 1 and paper 2 exams on material covered to date.</p>	<p>Revision lists will be provided to supplement class notes.</p>

Year 1: March – June (11 weeks)	
Content	Connections, Resources, Assessment
Familiarisation with Internal Assessment (IA) criteria through a guided investigation.	Mock IA to be executed in class and then submitted in two parts: <ul style="list-style-type: none"> • Background exploration, method and analysis (including errors) • Conclusion and evaluation (including references) • Peer assessment with teacher moderation Links: The similarity and differences between the IA requirements in the sciences should be emphasised.
Electricity and Magnetism, Fields and Electromagnetic Induction Charge, Electric field, Coulomb's law, Electric current, Direct current (dc), Potential difference, Circuit diagrams, Kirchoff's circuit laws, Heating effect of current and its consequences, Resistance expressed as $R = V/I$, Ohm's Law, Resistivity, Power dissipation, Cells, Internal resistance, Secondary cells, Terminal potential difference, Electromotive force (emf), Magnetic fields • Magnetic force	Possible activities include: Investigation of the relationship between potential difference and current in different systems. Comparison of resistivity of a variety of conductors; Software-based investigations of electrical cell design; Comparison of the life expectancy of various batteries. Measuring electromagnetic fields about a current carrying wire Measuring the Internal Resistance of a battery. TOK <ul style="list-style-type: none"> • Many early investigations into electricity had serious risk implications. Would such investigations be ethically acceptable today? Who should be responsible for setting the ethical standards for scientific research? • Electric cells as a form of electrical storage have had a profound impact on society despite the potential environmental issues surrounding their disposal. Should scientists be held morally responsible for the long-term consequences of their discoveries?
Additional Higher Level <i>Electrostatic fields, Electric potential, Field lines in electric fields, Equipotential surfaces in electrical, Potential and potential energy, Potential gradient and difference, Forces and inverse-square law behaviour</i>	TOK <ul style="list-style-type: none"> • Were electric and gravitational fields invented or discovered? Links: There are opportunities for linking with Calculus in Mathematics.
Internal Assessment background research In-class research and review of previous IA topics. Submission of RQ and Exploration/practical requirements	In-class research and review of previous IA topics. Submission of RQ and Exploration/practical requirements
Group 4 Project An interdisciplinary activity involving hands-on investigations in a natural environment, to which students bring a range of perspectives based on their other DP sciences, including Environmental systems and societies.	Carried out during a 6 day Science field course in Normandy. Collaboration is central to the experience. TOK: <ul style="list-style-type: none"> • What are the strengths and weakness of the scientific perspective to solving problems? CAS: Students monitor and report on a variety of physical (abiotic) factors in local waterways during their field trip at the end of year 1 Links: As this is an interdisciplinary exercise students will be encouraged to bring a range of perspectives based on their other DP subjects.

Year 2: Sept - December (12 weeks)	
Content	Connections, Resources, Assessment
<p>Atomic, Quantum, Nuclear, and Particle Physics Discrete energy and discrete energy levels, Transitions between energy levels, Radioactive decay, Fundamental forces and their properties, Alpha particles, beta particles and gamma rays, Half-life, Absorption characteristics of decay particles, Isotopes Background radiation, The unified atomic mass unit, Mass defect and nuclear binding energy, Nuclear fission and nuclear fusion, Quarks, leptons and their antiparticles, Hadrons, baryons and mesons, The conservation laws of charge, baryon number, lepton number and strangeness, The nature and range of the strong nuclear force, weak nuclear force and electromagnetic force, Exchange particles, Feynman diagrams, Confinement, The Higgs boson</p>	<p>Possible activities include: Nuclear reactions and particles physicals can be explored by simulation. Spectrum analysis of various gases. The half-life of beer foam (non-alcoholic beer). Planck's constant: simulation lab/ Estimate the value of Planck's Constant using the Photo-Electric Effect. TOK</p> <ul style="list-style-type: none"> • What are the relative significance of luck, intuition and reason role in scientific discoveries? • “One aim of the physical sciences has been to give an exact picture of the material world. One achievement of physics in the twentieth century has been to prove that this aim is unattainable.” – Jacob Bronowski. Can scientists ever be truly certain of their discoveries? • Einstein's realisation that mass and energy are equivalent was a major paradigm shift in physics. What is the significance of such paradigm shifts in the development of scientific knowledge and in other areas of knowledge? <p>Links: There are opportunities for making connections to the Atomic theory studies in Chemistry.</p>
<p>Additional Higher Level <i>Photons, The photoelectric effect, Matter waves, Pair production and pair annihilation, Quantization of angular momentum in the Bohr model for hydrogen, The wave function</i> <i>The uncertainty principle for energy and time and position and momentum, Tunnelling, potential barrier and factors affecting tunnelling probability, Rutherford scattering and nuclear radius</i> <i>Nuclear energy levels, The neutrino, The law of radioactive decay and the decay constant</i></p>	<p>Possible activities include: Investigating the photoelectric effect using LEDs. Radioactive decay and the photoelectric effect can be investigated using simulations. TOK</p> <ul style="list-style-type: none"> • Much of the knowledge about subatomic particles is based on the models one uses to interpret the data from experiments. How can we be sure that we are discovering an “independent truth” not influenced by our models? Is there such a thing as a single truth? <p>Links: There are opportunities for linking with Calculus in Mathematics</p>
<p>Physics Internal Assessment (Sept/October)</p>	<p>Staggered Internal assessment lab work (two groups) Final IA submissions: January</p>
<p>Additional Higher Level <i>Electromotive force (emf), Magnetic flux and magnetic flux linkage, Faraday's law of induction, Lenz's law, Average power and root mean square (rms) values of current and voltage, Transformers, Diode bridges, Half-wave and full-wave rectification, Capacitance, Dielectric materials, Capacitors in series and parallel, Resistor-capacitor (RC) series circuits, Time constant.</i></p>	<p>Possible activities include: Construction of a basic ac generator/ DC Electric Motor ; Investigation of variation of input and output coils on a transformer Investigating Wheatstone and Wien bridge circuits. Discharge of a Capacitor (Exponential Decay) The Principle of the Potentiometer Using an Oscilloscope Investigating Components having Non-Linear Characteristics The Faraday/Neumann Law of Electro-Magnetic Induction Links: There are opportunities for linking with Calculus in Mathematics</p>

Year 2: Jan – April	
Content	Connections, Resources, Assessment
<p>Energy Production Specific energy and energy density of fuel sources, Sankey diagrams, Primary energy sources, Electricity as a secondary and versatile form of energy, Renewable and non-renewable energy sources, Conduction, convection and thermal radiation Black-body radiation, Albedo and emissivity, The solar constant, The greenhouse effect, Energy balance in the Earth surface–atmosphere system,</p>	<p>Possible activities include: Simulations of energy exchange in the Earth surface/ atmosphere system. Investigating Energy density of different fuels. Investigating Greenhouse gases (The Physics Teacher Vol. 45, Sept. 2007). TOK</p> <ul style="list-style-type: none"> • The use of nuclear energy inspires a range of emotional responses from scientists and society. How can accurate scientific risk assessment be undertaken in emotionally charged areas? • The debate about global warming illustrates the difficulties that arise when scientific questions have a global impact on people’s lives. What are the responsibilities of science in such debates? <p>Links: There are opportunities for linking with Climate change and energy production in Environmental Systems and Societies, and Changing Production and consumption of energy resources in Geography.</p>
<p>Relativity (Current option of choice) Reference frames, Galilean relativity and Newton’s postulates concerning time and space, Maxwell and the constancy of the speed of light, Forces on a charge or current, The two postulates of special relativity Clock synchronization, The Lorentz transformations Velocity addition, Invariant quantities (space-time interval, proper time, proper length and rest mass) Time dilation, Length contraction, The muon decay experiment, Space time diagrams, World lines, The twin paradox</p>	<p>Possible activities include: Data Analysis of the Muon decay and Bertozzi experiments from videos. Twin paradox space-time via Hewitt video. Investigating the properties of curved space. TOK</p> <ul style="list-style-type: none"> • Can paradoxes be solved by reason alone, or do they require the utilization of other ways of knowing?
<p>Additional Higher Level <i>Total energy and rest energy, Relativistic momentum Particle acceleration, Electric charge as an invariant quantity, Photons, $MeV c^{-2}$ as the unit of mass and $MeVc^{-1}$ as the unit of momentum, The equivalence principle, The bending of light, Gravitational redshift and the Pound–Rebka–Snider experiment, Schwarzschild black holes, Event horizons, Time dilation near a black hole, Applications of general relativity to the universe as a whole</i></p>	<p>Possible activities include: Investigating the properties of curved space TOK</p> <ul style="list-style-type: none"> • Einstein described the cosmological constant as his “greatest blunder” but it was later vindicated through studies on dark energy. Have there been other examples of initially doubted claims later shown to be correct?
Year 2: Post-Bac Blanc – End of April	
Content	Connections, resources, assessment
<p>Completion of outstanding content Core and Options revision. Past papers. Practice questions. Student questions.</p>	

All material adapted from the IB subject guide