GRADE 12 ADVANCED PHYSICS LEVEL 2 - IB PHYSICS YEAR 2 FRAMEWORK

Contents

Physics is a two-year course. Students entering directly into grade 12 must have knowledge of grade 11th content. Only students not pursuing advanced studies will have time to revise some of the content. Nevertheless, due to the nature of the subject, students will be assessed in all content throughout the year.

THEMES AND CONTENT

- Atomic, Nuclear and Particle Physics – discrete energy and radioactivity, nuclear reactions, the structure of matter.
- Energy Production – Energy sources and thermal energy transfer.
- Astrophysics – Stellar quantities, stellar characteristics and stellar evolution, cosmology.

Those students wishing to pursue advanced studies (including IB HL) will also study the following:

- Wave Phenomena – Simple harmonic motion, single slit diffraction, interference, resolution, Doppler effect.
- Fields – Describing fields, fields at work.
- Electromagnetic Induction – Electromagnetic induction, transmission of power, capacitance.
- Quantum and Nuclear Physics – The interaction of matter with radiation, nuclear physics.
- Astrophysics – Stellar processes, further cosmology.

OTHER SKILLS AND EXPECTATIONS

MATH SKILLS

- Perform the basic arithmetic functions: addition, subtraction, multiplication and division.

- Carry out calculations involving means, decimals, fractions, percentages, ratios, approximations and reciprocals.
- Carry out manipulations with trigonometric functions.
- Use standard scientific notation.
- Use direct and inverse proportion.
- Solve simple algebraic equations and linear simultaneous equations.
- Plot graphs (with suitable scales and axes) including two variables that show linear and non-linear relationships.
- Interpret graphs, including the significance of gradients, changes in gradients, intercepts and areas.
- Draw lines (either curves or linear) of best fit on a scatter plot graph.
- On a best-fit linear graph, construct linear lines of maximum and minimum gradients with relative accuracy (by eye), taking into account all uncertainty bars.
- Interpret data presented in various forms (for example, bar charts, histograms and pie charts).
- Express uncertainties to one or two significant figures, with justification.

SCIENCE NOTEBOOK

- Science notebooks are an independent responsibility of the student.
- Students are expected to keep an organized notebook with notes from class, work done at home and data collected during labs.

SCIENTIFIC WRITING

- Students are expected to write an exploration section to every practical investigation done. This exploration must include:
    - Research question.
    - Scientific background information.
    - Detailed methodology for data collection and data processing.
    - Ethical, environment and safety considerations.
- Students are expected to present raw and processed data using an Excel spreadsheet.
    - Processed data includes, but is not limited to: converting units, performing calculations, doing averages, rounding, plotting data, adding trendlines, interpreting data from graphs and trendlines, and discussing quality of data and results.
- Students are expected to write an evaluation section for the investigations done. The evaluations must include:
    - The answer to the research question.
    - Comparison to the relevant accepted scientific context.
    - Strengths and weaknesses of the investigation emphasizing any methodological issues.
    - Realistic improvements and extensions.
- Students are expected to always quote their sources in all written assignments submitted.

USE OF A CALCULATOR

- Students are expected to use a graphic calculator both in class and during assessments (while there is no specific model which is not allowed at this level, there are calculators which are recommended and the list can be made available to students upon request).

INFORMATION TECHNOLOGY

- Students will be provided with a school computer containing all the required software, including but not limited to Excel, LoggerPro, Wolfram, etc. Students are expected to use them in the practical investigations done.
- Students are expected to appropriately select and quote online resources used.

SCIENCE LABORATORY SAFETY EXPECTATIONS

Students will be expected to learn and to follow the expectations for safe and appropriate practices during laboratory activity, as shown on the "Science Laboratory Safety" document.

ASSESSMENT

For students to receive a credit in science towards their High School Diploma, they must demonstrate proficiency on:

- In-class unit tests
- Laboratory Report
- Final Exam

Students who are pursuing the IB Diploma in addition to the High School Diploma must complete both years of the program and will submit the following works to the IBO which will assess them:

- Paper 1: multiple choice
    - SL – 30 marks, 45 minutes, 20% of final grade
    - HL – 40 marks, 60 minutes, 20% of final grade
- Paper 2: written response
    - SL – 50 marks, 75 minutes, 40% of final grade
    - HL – 95 marks, 135 minutes, 36% of final grade
- Paper 3: data analysis and option
    - SL – 25 marks, 60 minutes, 20% of final grade
    - HL – 45 marks, 75 minutes, 24% of final grade
- Internal Assessment (20% of final grade for both SL and HL)
- Group 4 Project

PERFORMANCE INDICATORS

Atomic, Nuclear and Particle Physics

Describe the emission and absorption spectrum of common gases.
Solve problems involving atomic spectra, including calculating the wavelength of photons emitted during atomic transitions.
Complete decay equations for alpha and beta decay.
Determine the half-life of a nuclide from a decay curve.
Investigate half-life experimentally (or by simulation).
Solve problems involving mass defect and binding energy.
Solve problems involving the energy released in radioactive decay, nuclear fission and nuclear fusion.

Sketch and interpret the general shape of the curve of average binding energy per nucleon against nucleon number.
Describe the Rutherford-Geiger-Marsden experiment that led to the discovery of the nucleus.
Apply conservation laws in particle reactions.
Describe protons and neutrons in terms of quarks.
Compare the interaction strengths of the fundamental forces, including gravity.
Describe the mediation of the fundamental forces through exchange particles.
Sketch and interpret simple Feynman diagrams.
Describe why free quarks are not observed

Energy production
Solve specific energy and energy density problems.
Sketch and interpret Sankey diagrams.
Describe the basic features of fossil fuel power stations, nuclear power stations, wind generators, pumped storage hydroelectric systems and solar power cells.
Solve problems relevant to energy transformations in the context of these generating systems.
Discuss safety issues and risks associated with the production of nuclear power.
Describe the differences between photovoltaic cells and solar heating panels.
Sketch and interpret graphs showing the variation of intensity with wavelength for bodies emitting thermal radiation at different temperatures.
Solve problems involving the Stefan–Boltzmann law and Wien's displacement law.
Describe the effects of the Earth's atmosphere on the mean surface temperature.
Solve problems involving albedo, emissivity, solar constant and the Earth's average temperature.

Astrophysics
Identify objects in the universe.
Qualitatively describe the equilibrium between pressure and gravitation in stars.
Use the astronomical unit (AU), light year (ly) and parsec (pc).
Describe the method to determine distance to stars through stellar parallax.
Solve problems involving luminosity, apparent brightness and distance.
Explain how surface temperature may be obtained from a star's spectrum.
Explain how the chemical composition of a star may be determined from the star's spectrum.
Sketch and interpret HR diagrams.
Identify the main regions of the HR diagram and describe the main properties of stars in these regions.
Apply the mass–luminosity relation.
Describe the reason for the variation of Cepheid variables.
Determine distance using data on Cepheid variables.
Sketch and interpret evolutionary paths of stars on an HR diagram.
Describe the evolution of stars off the main sequence.
Describe the role of mass in stellar evolution.
Describe both space and time as originating with the Big Bang.
Describe the characteristics of the CMB radiation.
Explain how the CMB radiation is evidence for a Hot Big Bang.
Solve problems involving z, R and Hubble's law.
Estimate the age of the universe by assuming a constant expansion rate

Wave Phenomena (HL/ADV)
Solve problems involving acceleration, velocity and displacement during simple harmonic - motion, both graphically and algebraically.
Describe the interchange of kinetic and potential energy during SHM.
Solve problems involving energy transfer during SHM, both graphically and algebraically.

Describe the effect of slit width on the diffraction pattern.
Determine the position of first interference minimum.
Qualitatively describe single-slit diffraction patterns produced from white light and from a range of monochromatic light frequencies.
Qualitatively describe two-slit interference patterns, including modulation by one-slit diffraction effect.
Sketch and interpret intensity graphs of double-slit interference patterns.
Solve problems involving the diffraction grating equation.
Describe conditions necessary for constructive and destructive interference from thin films, including phase change at interface and effect of refractive index.
Solve problems involving interference from thin films.
Solve problems involving the Rayleigh criterion for light emitted by two sources diffracted at a single slit.
Determine the resolvance of diffraction gratings.
Sketch and interpret the Doppler effect when there is relative motion between source and observer.
Describe situations where the Doppler effect can be utilized.
Solve problems involving the change in frequency or wavelength observed due to the Doppler effect to determine the velocity of the source/observer.

Fields (HL/ADV)
Represent sources of mass and charge, lines of electric and gravitational force, and field patterns using an appropriate symbolism.
Map fields using potential.
Describe the connection between equipotential surfaces and field lines.
Determine the potential energy of a point mass and the potential energy of a point charge.
Solve problems involving potential energy.
Determine the potential inside a charged sphere.
Solve problems involving the speed required for an object to go into orbit around a planet and for an object to escape the gravitational field of a planet.
Solve problems involving orbital energy of charged particles in circular orbital motion and masses in circular orbital motion.
Solve problems involving forces on charges and masses in radial and uniform fields.

Electromagnetic Induction (HL/ADV)
Describe the production of an induced emf by a changing magnetic flux and within a uniform magnetic field.
Solve problems involving magnetic flux, magnetic flux linkage and Faraday's law.
Explain Lenz's law through the conservation of energy.
Explain the operation of a basic ac generator, including the effect of changing the generator frequency.
Solve problems involving the average power in an ac circuit.
Solve problems involving step-up and step-down transformers.
Describe the use of transformers in an electrical power distribution.
Qualitatively describe the effect of adding a capacitor to a diode bridge rectification circuit.
Describe the effect of different dielectric materials on capacitance.
Solve problems involving parallel-plate capacitors.
Investigate combinations of capacitors in series or parallel circuits.
Determine the energy stored in a charged capacitor.
Describe the nature of the exponential discharge of a capacitor.
Solve problems involving the discharge of a capacitor through a fixed resistor.
Solve problems involving the time constant of an RC circuit for charge, voltage and current.

Quantum and Nuclear Physics (HL/ADV)
Discussing the photoelectric effect experiment and explaining which features of the experiment cannot be explained by the classical wave theory of light.
Solve photoelectric problems both graphically and algebraically.
Discuss experimental evidence for matter waves, including an experiment in which the wave nature of electrons is evident.
State order of magnitude estimates from the uncertainty principle.
Describe a scattering experiment including location of minimum intensity for the diffracted particles based on their de Broglie wavelength.
Explain deviations from Rutherford scattering in high energy experiments.
Describe experimental evidence for nuclear energy levels.
Solve problems involving the radioactive decay law.
Explain the methods for measuring short and long half-lives.

Astrophysics (HL/ADV)
Apply the Jeans criterion to star formation.
Describe the different types of nuclear fusion reactions taking place off the main sequence.
Describe the formation of elements in stars that are heavier than iron including the required increases in temperature.
Qualitatively describe the s and r processes for neutron capture.
Distinguish between type Ia and II supernovae.
Describe the cosmological principle and its role in models of the universe.
Describe rotation curves as evidence for dark matter.
Derive rotational velocity from Newtonian gravitation.
Describe and interpret the observed anisotropies in the CMB.
Derive critical density from Newtonian gravitation.
Sketch and interpret graphs showing the variation of the cosmic scale factor with time.
Describe qualitatively the cosmic scale factor in models with and without dark energy.