<u>PHYSICS UNIT 3 & 4 Course</u>

Unit 3 consists of two prescribed areas of study: Motion in one and two dimensions; Electronics and photonics.

Unit 4 consists of two prescribed areas of study: Electric power and Interactions of light and matter. There will be an additional Detailed Study, Materials and their use in structures, which will be an extended investigation after the completion of Unit 3 & 4 in Term 3.

PRACTICAL WORK
All practical work will be recorded in a student logbook; the book does not leave the school. Books will not be returned at the end of the year.

ASSESSMENT
Percentage contributions to the final assessment are as follows:

<u>Unit 3 School-assessed Course work: 16%</u>

- Topic tests/Data analysis
- Summary report of selected practical activities.

Allocation of Marks for each Outcome in Unit 3 (/70)

- Outcome 1: Motion – 40
- Outcome 2: Electronics - 30

<u>Unit 4 School-assessed Course work (includes Detailed Study): 24%</u>

- Topic tests
- Student-Designed Extended Practical Investigation

Allocation of Marks for each Outcome in Unit 3 (/100)

- Outcome 1: Electric power – 40
- Outcome 2: Light & Matter – 30
- Detailed Study: Materials - 30

<u>End of Year examination: 60%</u>

What you are expected to KNOW for the examination at the end of the year.

<u>Unit 3:</u>
Outcome 1 – Motion in one and two dimensions

- apply Newton's three laws of motion in situations where two or more coplanar forces act along a straight line and in two dimensions
- analyse the uniform circular motion of an object moving in a horizontal plane ($F_{net} = mv^2/R$) such as a vehicle moving around a circular road; a vehicle moving around a banked track; an object on the end of a string
- apply Newton's second law to circular motion in a vertical plane; consider forces at the highest and lowest positions only
- investigate and analyse the motion of projectiles near Earth's surface including a qualitative description of the effects of air resistance
- apply laws of energy and momentum conservation in isolated systems
- analyse impulse (momentum transfer) in an isolated system, for collisions between objects moving in a straight line ($F\Delta t = m\Delta v$)

- apply the concept of work done by a constant force
  - work done = constant force × distance moved in direction of net force
  - work done = area under force-distance graph
- analyse transformations of energy between: kinetic energy; strain potential energy; gravitational potential energy; and energy dissipated to the environment considered as a combination of heat, sound and deformation of material
  - kinetic energy, that is, $\frac{1}{2}mv^2$; elastic and inelastic collisions in terms of conservation of kinetic energy
  - strain potential energy, that is, area under force-distance graph including ideal springs obeying Hooke's Law, $\frac{1}{2}kx^2$
  - gravitational potential energy, that is, $mg\Delta h$ or from area under force-distance graph and area under field-distance graph multiplied by mass
- apply gravitational field and gravitational force concepts, $g = GM/r^2$ and $F = GM_1M_2/r^2$
- apply the concepts of weight ($W=mg$), apparent weight (reaction force, N), weightlessness ($W=0$) and apparent weightlessness ($N=0$)
- model satellite motion (artificial, moon, planet) as uniform circular orbital motion ($a = v^2/r = 4\pi^2r/T^2$)
- identify and apply safe and responsible practices when working with moving objects and equipment in investigations of motion.

Outcome 2 – Electronics and Photonics

- apply the concepts of current, resistance, potential difference (voltage drop) and power to the operation of electronic circuits comprising diodes, resistors, thermistors and photonic transducers including light dependent resistors (LDR), photodiodes and light emitting diodes (LED), ($V=IR$, $P=VI$)
- calculate the effective resistance of circuits comprising parallel and series resistance and unloaded voltage dividers
- describe energy transfers and transformations in opto-electronic devices
- describe the transfer of information in analogue form (excluding the technical aspects of modulation and demodulation) using the principles of:
  - light intensity modulation, that is, changing the intensity of the carrier wave to replicate the amplitude variation of the information signal so that the signal may propagate more efficiently
  - demodulation, that is, the separation of the information signal from the carrier wave
- design, investigate and analyse circuits for particular purposes using technical specifications related to potential difference (voltage drop), current, resistance, power, temperature and illumination for electronic components such as diodes, resistors, thermistors, light dependent resistors (LDR), photodiodes and light emitting diodes (LED)
- analyse voltage characteristics of amplifiers including linear voltage gain ($\Delta V_{out}/\Delta V_{in}$) and clipping
- identify and apply safe and responsible practices when conducting investigations involving electrical, electronic and photonic equipment.

Unit 4:

Outcome 1 – Electric Power

- apply a vector field model to magnetic phenomena including shapes and directions of fields produced by bar magnets, and by current-carrying wires, coils and solenoids
- calculate magnitudes, including determining the directions of, and magnetic forces on, current carrying wires, using $F = nI\ell B$ where the directions of I and B are either perpendicular or parallel to each other
- investigate and explain the operation of simple DC motors consisting of:
  - one coil, containing a number of loops of wire, which is free to rotate about an axis
  - two magnets providing a uniform magnetic field
  - a commutator
  - a DC power supply
- apply a field model to define magnetic flux Φ, using $\Phi = BA$ when the magnetic field is perpendicular to the area, and the qualitative effect of differing angles between the area and the field
- investigate and analyse the generation of emf, including AC voltage and calculations using induced emf, $\varepsilon = -n\Delta\Phi/\Delta t$, in terms of:
  - the rate of change of magnetic flux (Faraday's Law)
  - the direction of the induced current (Lenz's Law)
  - number of loops through which the flux passes
- explain the production of DC voltage in DC generators and AC voltage in alternators, including the use of commutators and slip rings respectively
- compare DC motors, DC generators and AC alternators
- investigate and compare sinusoidal AC voltages produced as a result of the uniform rotation of a loop in a constant magnetic field in terms of frequency, period, amplitude, peak-to-peak voltage ($V_{p\text{-}p}$) and peak-to-peak current ($I_{p\text{-}p}$)
- identify rms voltage as an AC voltage which produces the same power in a resistive component as a DC voltage of the same magnitude
- convert between rms, peak and peak-to-peak values of voltage and current
- analyse transformer action, modelled in terms of electromagnetic induction for an ideal transformer, $N_1 / N_2 = V_1 / V_2 = I_2 / I_1$
- analyse the supply of power as $P = VI$ and transmission losses using potential difference across transmission lines ($V = IR$) and power loss ($P = I^2R$)
- explain the use of transformers in an electricity distribution system
- identify and apply safe and responsible practices when working with electricity and electrical measurement.

Outcome 2 – Interaction of Light and Matter

- explain the results of Young's double slit experiment in terms of:
  - evidence for the wave-like nature of light
  - constructive and destructive interference of coherent waves in terms of path differences, $pd = n\lambda$, $pd = (n - ½)\lambda$ respectively
  - qualitative effect of wavelength, distance of screen and slit separation on interference patterns

- explain the effects of varying the width of gap or diameter of an obstacle on the diffraction pattern produced by light of appropriate wavelength in terms of the ratio λ/w (qualitative)
- analyse the photoelectric effect in terms of:
  - evidence for the particle-like nature of light
  - experimental data in the form of graphs of photocurrent versus electrode potential, and of kinetic energy of electrons versus frequency
  - kinetic energy of emitted photoelectrons, $E_{k_{max}} = hf - W$, using energy units of joule and electron-volt
  - effects of intensity of incident irradiation on the emission of photoelectrons
- describe why the wave model of light cannot account for the experimental photoelectric effect results
- interpret electron diffraction patterns as evidence for the wave-like nature of matter
- compare the diffraction patterns produced by photons and electrons
- calculate the de Broglie wavelength of matter, $\lambda = h/p$
- compare the momentum of photons and of matter of the same wavelength including calculations using $p = h/\lambda$
- explain the production of atomic absorption and emission spectra, including those from metal vapour lamps
- interpret spectra and calculate the energy of photons absorbed or emitted, $\Delta E = hf$
- analyse the absorption of photons by atoms, not including their bombardment by electrons, in terms of:
  - the change in energy levels of the atom due to electrons changing state
  - the frequency and wavelength of emitted photons, $E = hf = hc/\lambda$
- describe the quantised states of the atom in terms of electrons forming standing waves, recognising this as evidence of the dual nature of matter
- identify and apply safe and responsible practices when working with light sources, lasers and related equipment.

Detailed Study 3.2: Materials and their use in structures

- identify different types of external forces such as compression, tension and shear, that can act on a body, including gravitational forces
- evaluate the suitability of different materials for use in structures, including beams, columns and arches, by comparing tensile and compressive strength and stiffness or flexibility under load
- analyse the behaviour of materials under load in terms of extension and compression, including Young's modulus, $Y = \sigma/\varepsilon$
- calculate the stress and strain resulting from the application of compressive and tensile forces and loads to materials in structures, $\sigma = F/A$, $\varepsilon = \frac{\Delta\ell}{\ell}$
- describe brittle and ductile failure and apply data to predict brittle or ductile failure under load
- calculate the potential energy stored in a material under load (strain energy) using area under stress versus strain graph
- evaluate the toughness, as measured by the total area under the stress-strain graph, of a material tested to the point of failure

- describe elastic or plastic behaviour of materials under load and the resulting energy transformed to heat
- evaluate the suitability of a composite material for its use in a structure by considering its properties and the properties of the component materials (maximum of three components)
- calculate torque, $\tau = r \perp F$
- analyse translational forces and torques in simple structures, including uniform columns, struts, ties, beams, cables and simple two-dimensional trusses
- identify and apply safe and responsible practices when working with structures, materials and associated measuring equipment in investigations of materials.

End of Year Examination

- 15 minutes reading time and 2 hours 30 minutes writing time

- Section A will cover Area of study 1 and Area of study 2 of Units 3 and 4: Motion in one and two dimensions; Electronics and photonics; Electric power; and Interactions of light and matter. This section will be out of 128 marks. Marks allocated across each topic is roughly as follows:
    - Motion in one and two dimensions: 30–40 marks
    - Electronics and photonics: 20–30 marks
    - Electric power: 30–40 marks
    - Interactions of light and matter: 20–30 marks

- Section B will be all multiple choices on various Detailed Studies. Students will have to respond to only one detailed study. This section will comprise 11 multiple-choice questions worth two marks each, with a total of 22 marks.

- Total marks for the examination will be 150 marks. A formula sheet is provided in the examination.

- Approved materials in the examination:
    - A scientific calculator.
    - One folded A3 sheet OR two A4 sheets bound together by tape of pre-written notes that may be single- or double-sided. These notes may be typed or handwritten.