Physics Stage 6 Syllabus

NSW Education Standards Authority (NESA) 2017

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Course Overview

The Physics Stage 6 Syllabus is designed for the Australian curriculum in NSW. It provides students with opportunities to develop scientific understanding, skills, and values that will prepare them for further study in science-related fields and informed citizenship.

Indicative Hours:

- Year 11 Course: 120 hours
- Year 12 Course: 120 hours
- Depth Studies: 15 hours per year (included in above)
- Practical Investigations: Minimum 35 hours per year

Outcomes

Working Scientifically Skills

Code	Outcome Statement
PH11/12-1	develops and evaluates questions and hypotheses for scientific investigation
PH11/12-2	designs and evaluates investigations in order to obtain primary and secondary data and information
PH11/12-3	conducts investigations to collect valid and reliable primary and secondary data and information
PH11/12-4	selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
PH11/12-5	analyses and evaluates primary and secondary data and information

Code	Outcome Statement
PH11/12-6	solves scientific problems using primary and secondary data, critical thinking skills and scientific processes
PH11/12-7	communicates scientific understanding using suitable language and terminology for a specific audience or purpose

Year 11 Knowledge and Understanding

Code	Outcome Statement
PH11-8	describes and analyses motion in terms of scalar and vector quantities in two dimensions and makes quantitative measurements and calculations for distance, displacement, speed, velocity and acceleration
PH11-9	describes and explains events in terms of Newton's Laws of Motion, the law of conservation of momentum and the law of conservation of energy
PH11-10	explains and analyses waves and the transfer of energy by sound, light and thermodynamic principles
PH11-11	explains and quantitatively analyses electric fields, circuitry and magnetism

Year 12 Knowledge and Understanding

Code	Outcome Statement
PH12-12	describes and analyses qualitatively and quantitatively circular motion and motion in a gravitational field, in particular, the projectile motion of particles
PH12-13	explains and analyses the electric and magnetic interactions due to charged particles and currents and evaluates their effect both qualitatively and quantitatively
PH12-14	describes and analyses evidence for the properties of light and evaluates the implications of this evidence for modern theories of physics in the contemporary world
PH12-15	explains and analyses the evidence supporting the relationship between astronomical events and the nucleosynthesis of atoms and relates these to the development of the current model of the atom

Year 11 Course Structure

Component	Hours
Module 1: Kinematics	30
Module 2: Dynamics	30
Module 3: Waves and Thermodynamics	30
Module 4: Electricity and Magnetism	30
Depth Studies	*15 (included)*
Practical Investigations	*35*

Module 1: Kinematics

Outcomes: PH11-8, PH11-9

Inquiry Questions

1. How is the motion of an object moving in a straight line described and predicted?
2. How can the motion of objects be explained and analysed?

Content

Motion in a Straight Line

Students:

- describe uniform straight-line (rectilinear) motion and uniformly accelerated motion through:
  - qualitative descriptions
  - the use of scalar and vector quantities
- conduct a practical investigation to gather data to facilitate the analysis of instantaneous and average velocity through:
  - quantitative, first-hand measurements
  - the graphical representation and interpretation of data
- calculate the relative velocity of two objects moving along the same line using vector analysis

- conduct practical investigations, collecting primary data, to analyse uniformly accelerated motion in one dimension
- use appropriate mathematical representations of uniformly accelerated motion, including:
  - $v = u + at$
  - $s = ut + \frac{1}{2}at^2$
  - $v^2 = u^2 + 2as$
  - $s = \frac{(u+v)t}{2}$

Motion on a Plane

Students:

- analyse vectors in one and two dimensions to:
  - resolve a vector into two perpendicular components
  - add two perpendicular vector components to obtain a single vector
- represent the motion of objects in two dimensions using:
  - vector addition and resolution
  - algebraic and graphical techniques
- describe and analyse algebraically, graphically and with vector diagrams, the ways in which the motion of objects changes, including:
  - velocity
  - displacement
- describe and analyse, using vector analysis, the relative positions and motions of one object relative to another object on a plane
- analyse the relative motion of objects in two dimensions

Module 2: Dynamics

Outcomes: PH11-8, PH11-9

Inquiry Questions

1. How are forces produced between objects and what effects do forces produce?
2. How can the motion of objects be explained and analysed?

Content

Forces

Students:

- using Newton's Laws of Motion, describe static and dynamic interactions between two or more objects and the changes that result from:
  - a contact force
  - a force mediated by fields
- explore the concept of net force and equilibrium in one-dimensional and simple two-dimensional contexts using:
  - algebraic addition
  - vector addition
  - vector addition by resolution into components
- solve problems or make quantitative predictions about resultant and component forces by applying:
  - $\vec{F}_{AB} = -\vec{F}_{BA}$
- conduct a practical investigation to explain and predict the motion of objects on inclined planes

Forces, Acceleration and Energy

Students:

- apply Newton's first two laws of motion to a variety of everyday situations, including both static and dynamic examples, and include the role of friction
- investigate, describe and analyse the acceleration of a single object subjected to a constant net force and relate the motion of the object to Newton's Second Law of Motion through:
  - $\vec{F}_{net} = m\vec{a}$
- apply the special case of uniform circular motion to:
  - vertical motion in a loop
  - horizontal motion in a circle
  - a range of situations
- investigate the relationship between the rotation of mechanical systems and the applied torque
- solve problems, create models and make quantitative predictions using the equations of motion

Momentum, Energy and Simple Systems

Students:

- conduct an investigation to describe and analyse one-dimensional (straight-line) motion involving:
  - two or more objects
  - momentum
- evaluate the effects of forces involved in collisions and other interactions and analyse quantitatively the interactions using:
  - $p = mv$
  - impulse: $\Delta p = F\Delta t$
  - conservation of momentum: $p_{before} = p_{after}$
- describe and analyse qualitatively and quantitatively the relationship between force, time and momentum using:
  - impulse $\Delta p = F\Delta t$
- analyse and compare the momentum and kinetic energy of elastic and inelastic collisions
- investigate and describe the effects of friction on moving objects
- apply the law of conservation of mechanical energy to:
  - vertical fall: $PE + KE = constant$
  - inclined planes
  - projectiles
  - simple pendulum motion
- analyse quantitatively and predict the energy changes in a system using:
  - $W = Fs$, $W = Fs\cos\theta$
  - $KE = \frac{1}{2}mv^2$
  - $PE = mgh$

Module 3: Waves and Thermodynamics

Outcomes: PH11-10

Inquiry Questions

1. What are the properties of all waves and wave motion?
2. How do thermodynamic principles apply to systems?

Content

Wave Properties

Students:

- conduct a practical investigation involving the creation of mechanical waves in a variety of situations in order to explain:
  - the role of a medium in the propagation of mechanical waves
  - the transfer of energy involved in the propagation of mechanical waves
- conduct practical investigations to analyse and explain the behaviour of mechanical waves
- explain the relationship between the following quantities for a wave:
  - wavelength, frequency, period and velocity: $v = f\lambda$
- describe and analyse wave behaviour including:
  - reflection
  - refraction
  - diffraction
  - superposition

Wave Behaviour

Students:

- explain the phenomena of wave behaviour including:
  - reflection
  - refraction (Snell's Law)
  - diffraction
  - interference (superposition)
- investigate and model the behaviour of standing waves in strings to relate quantitatively the fundamental and harmonic frequencies of the waves to the physical characteristics of the medium
- analyse qualitatively and quantitatively the relationships of the wave nature of sound including:
  - beats: $f_{beat} = |f_2 - f_1|$
  - Doppler effect: $f' = f\frac{(v_{wave}+v_{observer})}{(v_{wave}-v_{source})}$

Sound Waves

Students:

- conduct a practical investigation to relate the pitch and loudness of sound to its wave characteristics
- model the behaviour of sound in air as a longitudinal wave
- relate the displacement of air molecules to variations in pressure
- investigate quantitatively the relationship between distance and intensity of sound
- conduct investigations to analyse the reflection, diffraction, resonance and superposition of sound waves

Ray Model of Light

Students:

- conduct practical investigations to analyse the formation of images in mirrors and lenses via reflection and refraction using the ray model of light
- conduct investigations to examine qualitatively and quantitatively the refraction and total internal reflection of light
- predict quantitatively, using Snell's Law, the refraction and total internal reflection of light
- solve problems using:
  - $n_x = \frac{c}{v_x}$
  - $n_1 \sin\theta_1 = n_2 \sin\theta_2$
  - $\sin\theta_c = \frac{n_2}{n_1}$
  - $I_1 r_1^2 = I_2 r_2^2$

Thermodynamics

Students:

- explain the relationship between the temperature of an object and the kinetic energy of the particles within it
- explain the concept of thermal equilibrium
- analyse the relationship between the change in temperature of an object and its specific heat capacity: $Q = mc\Delta T$
- investigate energy transfer by conduction, convection, and radiation
- conduct an investigation to analyse qualitatively and quantitatively the latent heat involved in a change of state
- apply: $\frac{Q}{t} = \frac{kA\Delta T}{d}$

Module 4: Electricity and Magnetism

Outcomes: PH11-11

Inquiry Questions

1. How do charged objects interact with other charged objects and with neutral objects?
2. How do the processes of the transfer and the transformation of energy occur in electric circuits?
3. How do magnetised and magnetic objects interact?

Content

Electrostatics

Students:

- conduct investigations to describe and analyse qualitatively and quantitatively:
  - processes by which objects become electrically charged
  - the forces produced by other objects as a result of their interactions with charged objects
- model the direction and strength of electric fields using field lines
- apply the electric field model using:
  - $\vec{F} = q\vec{E}$
  - $E = \frac{V}{d}$
  - $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$
- analyse equipotential lines: $V = \frac{\Delta U}{q}$

Electric Circuits

Students:

- investigate the flow of electric current in metals: $I = \frac{q}{t}$
- investigate current–voltage relationships using Ohm's Law:
  - $W = qV$
  - $V = IR$
- analyse energy conversion: $P = VI$, $E = Pt$
- investigate series and parallel circuits:

- $\Sigma I = 0$ (Kirchhoff's current law)
- $\Sigma V = 0$ (Kirchhoff's voltage law)
- $R_{Series} = R_1 + R_2 + ... + R_n$
- $\frac{1}{R_{Parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$

Magnetism

Students:

- investigate the force between magnetised and magnetic materials
- use magnetic field lines to model direction and strength
- investigate magnetic fields produced by wires and solenoids:
  - $B = \frac{\mu_0 I}{2\pi r}$
  - $B = \frac{\mu_0 N I}{L}$
- investigate and explain the process by which ferromagnetic materials become magnetised

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Year 12 Course Structure

Component	Hours
Module 5: Advanced Mechanics	30
Module 6: Electromagnetism	30
Module 7: The Nature of Light	30
Module 8: From the Universe to the Atom	30
Depth Studies	*15 (included)*
Practical Investigations	*35*

Module 5: Advanced Mechanics

Outcomes: PH11/12-4, PH11/12-5, PH11/12-6, PH11/12-7, PH12-12

Inquiry Questions

1. How can models that are used to explain projectile motion be used to analyse and make predictions?
2. Why do objects move in circles?
3. How does the force of gravity determine the motion of planets and satellites?
4. How is energy transferred and transformed in motion in gravitational fields?

Content

Projectile Motion

Students:

- analyse the motion of projectiles by resolving the motion into horizontal and vertical components, assuming:
  - constant vertical acceleration due to gravity
  - zero air resistance
- apply modelling to derive relationships between:
  - initial velocity, launch angle, maximum height
  - time of flight, final velocity, launch height
  - horizontal range (ACSPH099)
- conduct a practical investigation to validate these relationships
- solve problems using equations of motion

Circular Motion

Students:

- conduct investigations to explain relationships between:
  - centripetal force, mass, speed, radius
- analyse forces in circular motion situations:
  - cars on horizontal bends
  - mass on a string
  - objects on banked tracks (ACSPH100)
- solve problems using:
  - $a_c = \frac{v^2}{r}$
  - $v = \frac{2\pi r}{T}$

  - $F_c = \frac{mv^2}{r}$
  - $\omega = \frac{\Delta\theta}{t}$

- investigate energy and work in circular motion
- investigate torque: $\tau = r_{\perp}F = rF\sin\theta$

Motion in Gravitational Fields

Students:

- apply Newton's Law of Universal Gravitation:
  - $F = \frac{GMm}{r^2}$
  - $g = \frac{GM}{r^2}$
  - predict field strength at any point (ACSPH094, ACSPH095, ACSPH097)
- investigate orbital motion relating:
  - gravitational force, centripetal force, centripetal acceleration
  - mass, orbital radius, orbital velocity, orbital period
- predict orbital properties including geostationary orbits (ACSPH101)
- investigate Kepler's Laws:
  - $v = \frac{2\pi r}{T}$
  - $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$
- derive and apply:
  - escape velocity: $v_{esc} = \sqrt{\frac{2GM}{r}}$
  - gravitational PE: $U = -\frac{GMm}{r}$
  - total orbital energy: $U + K = -\frac{GMm}{2r}$
  - energy changes between orbits (ACSPH096)

Module 6: Electromagnetism

Outcomes: PH11/12-1 through PH11/12-5, PH12-13

Inquiry Questions

1. What happens to stationary and moving charged particles when they interact with an electric or magnetic field?
2. Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?
3. How are electric and magnetic fields related?
4. How has knowledge about the Motor Effect been applied to technological advances?

Content

Charged Particles in Fields

Students:

- investigate charged particles in electric fields:
  - $E = \frac{V}{d}$
  - $\vec{F}_{net} = m\vec{a}$, $\vec{F} = q\vec{E}$
  - $W = qV$, $W = qEd$, $K = \frac{1}{2}mv^2$ (ACSPH083)
- model trajectories in electric fields vs gravitational fields
- analyse interaction with magnetic fields:
  - $F = qv_{\perp}B = qvB\sin\theta$
- compare with uniform circular motion (ACSPH108)

The Motor Effect

Students:

- investigate current-carrying conductors in magnetic fields:
  - $F = lI_{\perp}B = lIB\sin\theta$ (ACSPH080, ACSPH081)
- investigate parallel current-carrying wires:
  - $\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$ (ACSPH081, ACSPH106)

Electromagnetic Induction

Students:

- describe magnetic flux: $\Phi = B_{\parallel}A = BA\cos\theta$ (ACSPH083, ACSPH107, ACSPH109)
- analyse Faraday's Law and Lenz's Law:
  - $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ (ACSPH081, ACSPH110)
- analyse transformers:
  - $\frac{V_p}{V_s} = \frac{N_p}{N_s}$
  - $V_pI_p = V_sI_s$ (ACSPH110)
- evaluate transformer efficiency limitations

Applications of the Motor Effect

Students:

- investigate DC motor operation:
  - torque: $\tau = nIA_{\perp}B = nIAB\sin\theta$
  - back emf effects (ACSPH108)
- analyse DC/AC generators and AC induction motors (ACSPH110)
- relate Lenz's Law to conservation of energy

Module 7: The Nature of Light

Outcomes: PH11/12-1 through PH11/12-4, PH11/12-7, PH12-14

Inquiry Questions

1. What is light?
2. What evidence supports the classical wave model of light and under what circumstances does this model not apply?
3. How are light and matter related?
4. How does the behaviour of light affect concepts of time, space and matter?

Content

Electromagnetic Spectrum

Students:

- investigate Maxwell's electromagnetic theory:
  - unification of electricity and magnetism
  - prediction of EM waves and velocity (ACSPH113)
- describe production and propagation of EM waves (ACSPH112, ACSPH113)
- investigate methods to determine speed of light (ACSPH082)
- investigate spectroscopy for element identification
- investigate stellar spectra for temperature, velocity, density, composition

Light: Wave Model

Students:

- investigate diffraction of light (ACSPH048, ACSPH076)
- investigate interference using double slits and gratings:
  - $d \sin\theta = m\lambda$ (ACSPH116, ACSPH117, ACSPH140)
- analyse Newton's and Huygens' models (ACSPH050, ACSPH118, ACSPH123)
- investigate polarisation using Malus' Law:
  - $I = I_{max} \cos^2\theta$ (ACSPH050, ACSPH076, ACSPH120)

Light: Quantum Model

Students:

- analyse black body radiation and Wien's Law:
  - $\lambda_{max} = \frac{b}{T}$ (ACSPH137)
- investigate photoelectric effect evidence (ACSPH087, ACSPH123, ACSPH137)
- analyse photoelectric effect:
  - $K_{max} = hf - \phi$ (ACSPH119)

Light and Special Relativity

Students:

- analyse Einstein's two postulates (ACSPH131)
- investigate time dilation and length contraction:
  - $t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$
  - $l = l_0\sqrt{1-\frac{v^2}{c^2}}$
- analyse evidence: muons, atomic clocks, particle accelerators
- describe relativistic momentum:
  - $p_v = \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}}$ (ACSPH133)
- apply mass–energy equivalence:
  - $E = mc^2$ (ACSPH134)

Module 8: From the Universe to the Atom

Outcomes: PH11/12-5, PH11/12-6, PH11/12-7, PH12-15

Inquiry Questions

1. What evidence is there for the origins of the elements?
2. How is energy produced in stars?
3. How do the properties of the nucleus give rise to the properties of matter?
4. What are the implications of mass defect and binding energy for nuclei?

Content

Origins of the Elements

Students:

- investigate transformation of radiation into matter after the Big Bang
- investigate Hubble's discovery of Universe expansion (ACSPH138)
- analyse Einstein's mass–energy equivalence in stellar reactions (ACSPH031)
- account for emission and absorption spectra vs black body spectrum (ACSPH137)
- investigate stellar spectra classification

- investigate H-R diagram for star characteristics and evolution
- investigate nucleosynthesis: proton–proton chain, CNO cycle

Structure of the Atom

Students:

- investigate evidence for electrons:
  - cathode ray experiments
  - Thomson's charge-to-mass experiment
  - Millikan's oil drop experiment (ACSPH026)
- investigate nuclear model evidence:
  - Geiger-Marsden experiment
  - Rutherford's atomic model
  - Chadwick's neutron discovery (ACSPH026)

Quantum Mechanical Nature of the Atom

Students:

- assess limitations of Rutherford and Bohr models
- investigate Balmer series in hydrogen (ACSPH138)
- relate quantised energy levels to line emission:
  - $E = hf$
  - $E = \frac{hc}{\lambda}$
  - $\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ (ACSPH136)
- investigate de Broglie matter waves:
  - $\lambda = \frac{h}{mv}$ (ACSPH140)
- analyse Schrödinger's contribution

Properties of the Nucleus

Students:

- analyse radioactive decay: alpha, beta, gamma (ACSPH028, ACSPH030)
- examine half-life model:
  - $N_t = N_0 e^{-\lambda t}$
  - $\lambda = \frac{\ln 2}{t_{1/2}}$ (ACSPH029)

- analyse mass defect and binding energy:
  - $E = mc^2$
  - binding energy per nucleon curve
- compare fission and fusion:
  - energy release mechanisms
  - conditions required
- investigate applications: nuclear reactors, weapons, medical isotopes

Deep Inside the Atom

Students:

- investigate the Standard Model of matter
- analyse particle accelerator evidence for quarks
- describe fundamental particles: leptons, quarks, bosons
- analyse particle interactions and conservation laws

Working Scientifically Skills

Working Scientifically skills are integrated throughout all modules. The seven skills are:

1. **Questioning and Predicting** - developing and evaluating inquiry questions and hypotheses
2. **Planning Investigations** - justifying selection of equipment, assessing risks, identifying variables
3. **Conducting Investigations** - employing safe work practices, using appropriate technologies
4. **Processing Data and Information** - selecting and representing data using appropriate formats
5. **Analysing Data and Information** - deriving trends, assessing error, evaluating reliability
6. **Problem Solving** - using modelling to explain phenomena and make predictions
7. **Communicating** - using appropriate scientific language and notations

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Depth Studies

Depth studies provide students with opportunities to pursue their interests in physics. Requirements:

- Minimum 15 hours per year
- Can be one or multiple investigations
- Must relate to one or more syllabus outcomes
- Can include practical investigations, secondary research, or fieldwork

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Assessment

Assessment requirements are detailed in the Physics Stage 6 Assessment and Reporting document. Key components:

Year 11

Component	Weighting
Skills in Working Scientifically	60%
Knowledge and Understanding	40%

Year 12

Component	Weighting
Skills in Working Scientifically	60%
Knowledge and Understanding	40%

HSC Examination

- 3 hours duration
- Section I: 20 multiple choice questions (20 marks)
- Section II: Short answer and extended response questions (80 marks)

Glossary

Key terms are defined in the official NESA Physics Stage 6 Syllabus Glossary.
