NSW Education Standards Authority

Mathematics Extension 2 11–12 (2024)

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NESA acknowledges Traditional Owners and Custodians of Country throughout NSW, and pays respect to Elders past and present. NESA recognises Aboriginal Peoples' continuing Cultures and Connections to lands, waters, skies and Community.

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Mathematics Extension 2 11–12 (2024)

Implementation from 2026

The new Mathematics Extension 2 11–12 Syllabus (2024) is to be implemented from 2026 and will replace the **Mathematics Extension 2 Stage 6 Syllabus (2017)**.

2026, Term 4

- Start teaching the new syllabus for Year 12
- Start implementing the new Year 12 school-based assessment requirements

2027

- First HSC examination for the new syllabus

Overview

Syllabus overview

Organisation of Mathematics Extension 2 Year 12

The organisation of outcomes and content for Mathematics Extension 2 Year 12 highlights the important role Working mathematically plays across all areas of mathematics and reflects the strengthened connections between concepts. Working mathematically has been embedded in the outcomes and content of the syllabus.

Mathematics Extension 2 Year 12 outcomes and their related content are organised into 5 areas of study:

- Proof
- Vectors
- Complex numbers
- Calculus
- Mechanics.

Figure 1 shows the organisation of Mathematics Extension 2 Year 12.

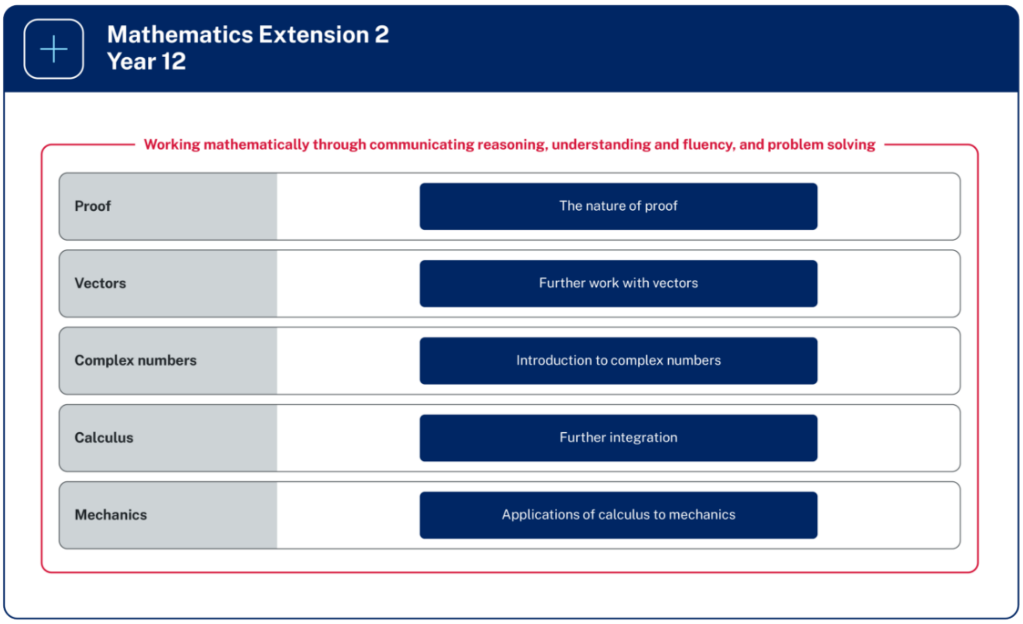


Figure 1: The organisation of Mathematics Extension 2 Year 12

Image long description: Five rows represent the areas of study for Mathematics Extension 2 Year 12. The Proof area of study includes the focus area The nature of proof. The Vectors area of study includes the focus area Further work with vectors. The Complex numbers area of study includes the focus area Introduction to complex numbers. The Calculus area of study includes the focus area Further integration. The Mechanics area of study includes the focus area Applications of calculus to mechanics. All content is surrounded by a box labelled with the phrase, 'Working mathematically through communicating reasoning, understanding and fluency, and problem solving'.

Protocols for collaborating with Aboriginal and Torres Strait Islander Communities

NESA is committed to working in partnership with Aboriginal Communities and supporting teachers, schools and schooling sectors to improve educational outcomes for young people.

It is important to respect appropriate ways of interacting with Aboriginal Communities and Cultural material when teachers plan, program and implement learning experiences that focus on Aboriginal and Torres Strait Islander Priorities.

Indigenous Cultural and Intellectual Property (ICIP) protocols need to be followed. Aboriginal and Torres Strait Islander Peoples' ICIP protocols include Cultural Knowledges, Cultural Expression and Cultural Property and documentation of Aboriginal and Torres Strait Islander Peoples' Identities and lived experiences. It is important to recognise the diversity and complexity of different Cultural groups in NSW, as protocols may differ between local Aboriginal Communities.

Teachers should work in partnership with Elders, parents, Community members, Cultural Knowledge Holders, or a local, regional or state Aboriginal Education Consultative Group. It is important to respect Elders and the roles of men and women. Local Aboriginal Peoples should be invited to share their Cultural Knowledges with students and staff when engaging with Aboriginal histories and Cultural Practices.

Course description

Mathematics Extension 2 focuses on key ideas of algebra and calculus and appreciation of mathematical invention, intuition and exploration. Mathematics Extension 2 extends students' conceptual knowledge and understanding through exploration of new areas of mathematics not covered in Mathematics Advanced and Mathematics Extension 1.

What students learn

Through the study of Mathematics Extension 2, students:

- develop strong knowledge, understanding and skills in Working mathematically and in communicating concisely and precisely
- acquire knowledge, understanding and skills in relation to mathematical concepts that have applications in an increasing number of contexts
- gain an appropriate mathematical background for future pathways which are founded in mathematics and its applications.

Course structure and requirements

Year 12 course structure

Area of study	Focus area
Proof	The nature of proof
Vectors	Further work with vectors
Complex numbers	Introduction to complex numbers
Calculus	Further integration
Mechanics	Applications of calculus to mechanics

Safety and risk management

Schools are required to ensure they follow safety and risk management in delivering the *Mathematics Extension 2 Year 12 Syllabus*.

Course enrolment details

Mathematics Extension 2 Year 12

- Course number: 15260
- Course hours: 60
- Course units: 1
- Enrolment type: Elective
- Endorsement type: Board developed

Exclusions

- Mathematics Standard 1 (Year 12, 2 units): 15231
- Mathematics Standard 1 (Examination) (Year 12): 15232
- Mathematics Standard 2 (Year 12, 2 units): 15236

- Mathematics Life Skills (Year 12, 2 units): 17680

Prerequisites

- Mathematics Advanced (Year 11, 2 units): 11255
- Mathematics Extension 1 (Year 11, 1 unit): 11250

Corequisites

- Mathematics Advanced (Year 12, 2 units): 15255
- Mathematics Extension 1 (Year 12, 1 unit): 15250

HSC information

Information about curriculum requirements for the HSC are available on Assessment Certification Examination (ACE).

Rationale

Mathematics in the Stage 6 Curriculum

Mathematical ideas have evolved and continue to develop across cultures and have been practised in Australia by Aboriginal and Torres Strait Islander Peoples for thousands of years.

The utility of mathematics extends from counting and measuring to explaining real-world phenomena and to the inherent beauty of mathematics. Mathematics has evolved in sophisticated ways to become the language used to describe and understand much of the modern world.

The creative application of mathematical concepts is integral to scientific and technological advancement. The symbolic nature of mathematics provides a precise means of communication.

The Mathematics Stage 6 syllabuses are designed to offer students opportunities to think mathematically. Mathematical thinking is supported through questioning, communicating, reasoning, reflecting and the use of appropriate technology, and is encouraged through providing students with opportunities to generalise, challenge, find connections and to think critically and creatively. Using mathematical thinking, students apply their knowledge and skills to deepen their understanding of the world.

Mathematics Extension 2

Mathematics Advanced, Mathematics Extension 1 and Mathematics Extension 2 form a continuum to provide students with opportunities to acquire knowledge, understanding and skills in mathematical concepts at progressively higher levels and with applications in an increasing number of contexts. Mathematics Advanced, Mathematics Extension 1 and Mathematics Extension 2 provide students with opportunities to learn about the interconnected nature of mathematics, its beauty and its functionality. The concepts and techniques of differential and integral calculus are the basis of the courses.

Mathematics Extension 2 provides students with the opportunity to develop strong mathematical manipulation skills and a deep understanding of the fundamental ideas of algebra and calculus. Students strengthen their appreciation of mathematics as an activity with its own intrinsic value, involving invention, intuition and exploration. Mathematics Extension 2 extends students’ conceptual knowledge and understanding through the exploration of new areas of mathematics not seen in Mathematics Advanced and Mathematics Extension 1.

Mathematics Extension 2 provides a basis for a wide range of applications of mathematics as well as a strong foundation for further study of the subject at tertiary level.

Aim

The aim of Mathematics Extension 2 is for students to extend their knowledge from Mathematics Extension 1 and their understanding of Working mathematically. They enhance their skills to solve difficult problems, generalise, make connections in mathematics, and become fluent in using mathematical models and language to communicate in a concise and systematic manner.

Table of outcomes

MAO-WM-01 Working mathematically

develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly

This outcome is aligned to all content in each Stage.

Year 12
ME2-12-01 selects and applies the language, notation and methods of proof to prove results
ME2-12-02 uses vectors to model lines and curves, solve problems, and prove results involving geometry and coordinate geometry
ME2-12-03 uses algebraic and geometric representations of complex numbers to prove results and model and solve problems
ME2-12-04 selects and uses techniques of integration to solve problems
ME2-12-05 uses mechanics to model and solve practical problems

Outcomes and content for Year 12

The nature of proof

Outcomes

A student:

- develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
- selects and applies the language, notation and methods of proof to prove results **ME2-12-01**

Content

The language and notation of proof

- Use the formal language of proof, including the terms 'statement', 'proposition', 'implication', 'converse', 'negation', 'contradiction', 'counterexample', 'equivalence' and 'contrapositive'
- Define a statement or proposition as a sentence that is either true or false, but not both
- Use the notation $P \wedge Q$ to represent the statement 'P and Q' and the notation $P \vee Q$ to represent the statement 'P or Q'
- Define and use the negation of P as 'not P', denoted $\neg P$ or $\sim P$
- Define an implication as an 'if–then' statement, where 'if P then Q' is denoted $P \Rightarrow Q$ or $P \rightarrow Q$, read as 'P implies Q'
- Use the quantifiers 'for all' ($\forall$), and 'there exists' ($\exists$) in formulating statements
- Negate statements including the negation of a negation $\neg(\neg P) = P$, the negation of an implication $\neg(P \Rightarrow Q) = (P \text{ and } \neg Q) = (P \wedge \neg Q)$, the negation $\neg(P \text{ and } Q) = (\neg P \text{ or } \neg Q)$, that is $\neg(P \wedge Q) = (\neg P \vee \neg Q)$, and the negation $\neg(P \text{ or } Q) = (\neg P \text{ and } \neg Q)$, that is $\neg(P \vee Q) = (\neg P \wedge \neg Q)$, noting that $P \Rightarrow Q = \neg(P \text{ and } \neg Q) = (\neg P \text{ or } Q)$, that is
$$P \Rightarrow Q = \neg(P \wedge \neg Q) = (\neg P \vee Q)$$
- Define and use the converse of 'if P then Q' as 'if Q then P', denoted $Q \Rightarrow P$
- Recognise that the converse of a true implication may or may not be true
- Define equivalence of P and Q, as both $P \Rightarrow Q$ and $Q \Rightarrow P$, denoted $P \Leftrightarrow Q$ or $P \leftrightarrow Q$, read as 'P if and only if Q', commonly abbreviated 'P iff Q'
- Define the contrapositive of 'if P then Q' as 'if not Q then not P', denoted $\neg Q \Rightarrow \neg P$
- Recognise that an implication is equivalent to its contrapositive, that is $(P \Rightarrow Q) \Leftrightarrow (\neg Q \Rightarrow \neg P)$, and use this to prove results

Illustrations of proofs

- Use proof by contradiction to prove the truth of mathematical statements
- Use examples and counterexamples to test the truth of mathematical statements
- Prove results involving integers

Example(s):

Prove result involving odd and even integers or divisibility.

Proof of inequalities

- Prove results involving inequalities using the definition of $a > b$ for real a and b, that is $a > b$ if and only if $a - b > 0$
- Prove results involving inequalities using the property that squares of real numbers are non-negative, in particular $(a \pm b)^2 \geq 0$
- Prove and use results for numbers: if $a > b$ then $a \pm c > b \pm c$; if $a > b > 0$ then $\frac{1}{b} > \frac{1}{a} > 0$ and vice versa; if $|a| > |b|$ then $a^2 > b^2$ and vice versa; if $a > b$ and $b > c$ then $a > c$; if $a > b$ and $c > d$ then $a + c > b + d$; if $a > b$ and $c > 0$ then $ac > bc$; if $a > b$ and $c < 0$ then $ac < bc$
- Prove and use the triangle inequality $|a + b| \leq |a| + |b|$ and interpret the inequality geometrically
- Establish and use the relationship between the arithmetic mean and geometric mean for two non-negative numbers, that is $\forall a,b \geq 0, \frac{a+b}{2} \geq \sqrt{ab}$
- Prove results involving inequalities using previously obtained or known inequalities

Example(s):

Prove $x^2 + y^2 \geq 2xy$ and use the result to prove other inequalities.

- Prove inequalities involving geometry
- Prove results using the squeeze theorem: if $f(x) \leq g(x) \leq h(x)$ for all x that are near k, but not necessarily at k, and $\lim_{x \to k} f(x) = \lim_{x \to k} h(x) = L$, then $\lim_{x \to k} g(x) = L$
- Prove inequalities using graphical or calculus techniques or a combination of both

Example(s):

Prove results by considering where functions are increasing or decreasing.

Further proof by mathematical induction

- Prove results involving trigonometric, logarithmic, exponential, polynomial or other identities, including the binomial theorem, using mathematical induction
- Prove inequality results using mathematical induction
- Prove results in calculus using mathematical induction
- Explain that a recursive formula, or recurrence relation, is a formula that defines each term of a sequence using a preceding term
- Prove results involving first-order recursive formulas using mathematical induction
- Prove geometric results using mathematical induction

Further work with vectors

Outcomes

A student:

- develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
- uses vectors to model lines and curves, solve problems, and prove results involving geometry and coordinate geometry **ME2-12-02**

Content

Vector equations of lines and curves

- Define the direction vector of a straight line and identify that a straight line through two points P and Q has $\overrightarrow{PQ}$ as a possible direction vector in both two dimensions and three dimensions
- Establish the relationship between the gradient, m, of a straight line in two dimensions and its direction vector
- Examine and use $\mathbf{r} = \mathbf{a} + \lambda\mathbf{b}$ as the vector equation of a straight line in two dimensions and three dimensions to solve problems, where $\mathbf{r}$ is the position vector of a point on the line, $\mathbf{a}$ is the position vector of a particular point on the line, $\mathbf{b}$ is a direction vector of the line and λ is a scalar parameter
- Identify $\mathbf{r} = \mathbf{p} + \lambda(\mathbf{q} - \mathbf{p})$ as one possible vector equation for the straight line through points P and Q, where $\mathbf{p}$ and $\mathbf{q}$ are the position vectors of P and Q respectively, noting its equivalence with the form $\mathbf{r} = \lambda\mathbf{q} + (1 - \lambda)\mathbf{p}$, and establish the correspondence between the value of λ and the position of the point specified by it along the line
- Express a line in two dimensions given in gradient–intercept form ($y = mx + c$) as a vector equation, and vice versa
- Determine when two lines in vector form are parallel in two dimensions and three dimensions
- Determine whether a given point lies on a line in vector form
- Determine using vector methods whether three points are collinear in two dimensions and three dimensions
- Determine the point of intersection of two non-parallel lines expressed as vector equations in two dimensions
- Determine whether two distinct lines $\mathbf{r_1} = \mathbf{a_1} + \lambda_1\mathbf{b_1}$ and $\mathbf{r_2} = \mathbf{a_2} + \lambda_2\mathbf{b_2}$ in three dimensions intersect, and if so, find the unique value of either λ_1 or λ_2 corresponding to the point of intersection and determine its coordinates
- Define skew lines in three dimensions and apply vector methods to determine whether two lines in three dimensions are skew
- Recognise that a parametrically defined curve in two dimensions or three dimensions can be expressed as a vector equation: $\mathbf{r} = \begin{pmatrix} x(t) \\ y(t) \end{pmatrix}$ or $\mathbf{r} = \begin{pmatrix} x(t) \\ y(t) \\ z(t) \end{pmatrix}$, where t is a parameter
- Examine and identify curves given as vector equations in two dimensions and three dimensions using graphing applications
- Identify the vector equation of a curve given its graph
- Recognise $\mathbf{r} = r\cos(\theta)\,\mathbf{i} + r\sin(\theta)\,\mathbf{j}$ and $|\mathbf{r}| = r$ as vector equations of a circle in two dimensions with radius r centred at the origin

- Recognise $\mathbf{r} = (r\cos(\theta) + x_C)\mathbf{i} + (r\sin(\theta) + y_C)\mathbf{j}$ and $|\mathbf{r} - \mathbf{c}| = r$ as vector equations of a circle in two dimensions with radius r and centre C with position vector $\mathbf{c} = \binom{x_C}{y_C}$
- Recognise $|\mathbf{r} - \mathbf{c}| = r$ as the vector equation of a sphere in three dimensions with radius r and centre C with position vector $\mathbf{c}$
- Use the circle equations and sphere equations to solve problems

Example(s):

Let S be a sphere with equation $\left|\mathbf{r} - \begin{pmatrix} 2 \\ -3 \\ 3 \end{pmatrix}\right| = 15$. Show that the point $P(1,-1,2)$ lies inside the sphere S.

- Determine the Cartesian equation of a curve in two dimensions given its vector equation and graph the curve, where the curve is within the scope of this syllabus

Example(s):

A curve has vector equation $\mathbf{r} = (2\sin t - 1)\mathbf{i} + (2\cos t + 3)\mathbf{j}$. Write down a pair of parametric equations for this curve. Determine the Cartesian equation for this curve. Sketch the curve on a Cartesian plane.

Vectors and geometry

- Examine and use properties of the scalar (dot) product, including commutativity ($\mathbf{a} \cdot \mathbf{b} = \mathbf{b} \cdot \mathbf{a}$), distributivity ($\mathbf{a} \cdot (\mathbf{b} + \mathbf{c}) = \mathbf{a} \cdot \mathbf{b} + \mathbf{a} \cdot \mathbf{c}$) and scalar multiplication ($k(\mathbf{a} \cdot \mathbf{b}) = (k\mathbf{a}) \cdot \mathbf{b} = \mathbf{a} \cdot (k\mathbf{b})$)
- Establish and use the results $\mathbf{i} \cdot \mathbf{i} = \mathbf{j} \cdot \mathbf{j} = \mathbf{k} \cdot \mathbf{k} = 1$ and $\mathbf{i} \cdot \mathbf{j} = \mathbf{j} \cdot \mathbf{k} = \mathbf{k} \cdot \mathbf{i} = 0$
- Prove and use the Cauchy–Schwarz inequality for vectors: $|\mathbf{a} \cdot \mathbf{b}| \leq |\mathbf{a}||\mathbf{b}|$
- Define the medians, altitudes, perpendicular bisectors and angle bisectors of a triangle and recognise these definitions in vector proofs
- Solve problems and prove geometric results in two dimensions and three dimensions using vectors

Introduction to complex numbers

Outcomes

A student:

- develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
- uses algebraic and geometric representations of complex numbers to prove results and model and solve problems **ME2-12-03**

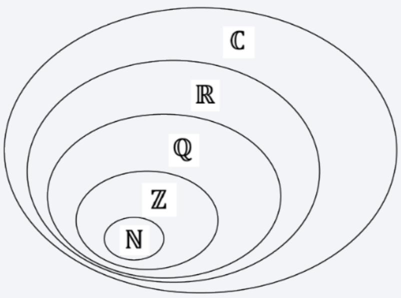
Content

Arithmetic of complex numbers

- Define the number i by $i^2 = -1$
- Use the number i to solve quadratic equations of the form $x^2 + k = 0$ where k is a positive real number
- Define the complex numbers (C) as the set of numbers of the form $a + ib$, where a and b are real numbers
- Use complex numbers to express the roots of quadratic equations of the form $ax^2 + bx + c = 0$, where a, b and c are real numbers and the discriminant $\Delta = b^2 - 4ac < 0$
- Refer to a as 'the real part of the complex number $z = a + ib$', denoted by $\mathrm{Re}(z)$
- Refer to b as 'the imaginary part of the complex number $z = a + ib$', denoted by $\mathrm{Im}(z)$
- Classify numbers as belonging to the set of natural numbers (N), integers (Z), rational numbers (Q), real numbers (R) or complex numbers (C), each of which is an extension of the previous

Example(s):

Classify each of the numbers $5, \frac{18}{6}, -8, \sin\frac{\pi}{6}, \frac{22}{7}, \sqrt{5}, \sqrt{49}$ and $2 + 3i$ using the smallest possible subset presented in the number category Venn diagram below.



- Identify and use the condition for two complex numbers z_1 and z_2 to be equal, that is $z_1 = z_2$ if and only if $\mathrm{Re}(z_1) = \mathrm{Re}(z_2)$ and $\mathrm{Im}(z_1) = \mathrm{Im}(z_2)$
- Define and perform complex number addition, subtraction and multiplication, with and without digital tools
- Define the complex conjugate of a complex number $z = a + ib$ as $\bar{z} = a - ib$ and use it to solve problems
- Define and calculate the modulus of a complex number $z = a + ib$ as $|z| = \sqrt{z\bar{z}} = \sqrt{a^2 + b^2}$

- Establish relationships $\text{Re}(z) = \frac{z+\bar{z}}{2}$ and $\text{Im}(z) = \frac{z-\bar{z}}{2i}$ and $\frac{1}{z} = \frac{\bar{z}}{|z|^2}$, $z \neq 0$, and use them to solve problems
- Divide one complex number by another non-zero complex number, with and without digital tools, and give the result in the form $a + ib$
- Find the two square roots of a complex number $z = a + ib$

Geometric representation of complex numbers

- Plot the complex number $z = a + ib$ as a point on the complex plane with and without graphing applications
- Define and calculate the argument of a non-zero complex number $z = a + ib$ as $\arg(z) = \theta$, where θ satisfies $\sin\theta = \frac{b}{|z|}$ and $\cos\theta = \frac{a}{|z|}$, noting that the argument has multiple values that differ by multiples of 2π
- Define and use the principal argument $\text{Arg}(z)$ of a non-zero complex number z as the unique value of the argument in the interval $(-\pi, \pi]$
- Define and use complex numbers in polar or modulus–argument form that expresses a complex number in terms of its modulus and argument, $z = r(\cos\theta + i\sin\theta)$, where r is its modulus and θ is an argument of z, and represent complex numbers in this form on the complex plane
- Use multiplication, division and powers of complex numbers in polar form and interpret these geometrically
- Convert between complex numbers in Cartesian form and polar form and use complex numbers in Cartesian form and polar form to solve problems
- Prove and use identities involving the modulus of complex numbers: $|z_1 z_2| = |z_1||z_2|$, $\left|\frac{z_1}{z_2}\right| = \frac{|z_1|}{|z_2|}$ and $|z^n| = |z|^n$, where n is an integer
- Prove and use identities involving the argument of complex numbers: $\arg(z_1 z_2) = \arg(z_1) + \arg(z_2)$, $\arg\left(\frac{z_1}{z_2}\right) = \arg(z_1) - \arg(z_2)$ and $\arg(z^n) = n\arg(z)$ where n is an integer
- Prove and use identities involving the complex conjugate of complex numbers: $\overline{z_1} + \overline{z_2} = \overline{z_1 + z_2}$, $\overline{z_1}\,\overline{z_2} = \overline{z_1 z_2}$
- Prove and use the triangle inequality $|z_1 + z_2| \leq |z_1| + |z_2|$ for complex numbers z_1 and z_2

Solving equations with complex numbers

- Solve quadratic equations of the form $ax^2 + bx + c = 0$, where a, b and c are complex numbers
- Recognise that solutions to quadratic equations with real coefficients are complex conjugates of each other and use this to solve problems
- Prove the complex conjugate root theorem: if the complex number $z = a + ib$ is a root of the polynomial equation $P(x) = 0$ with real coefficients, then the complex conjugate $\bar{z} = a - ib$ is also a root of $P(x) = 0$
- Solve problems involving complex conjugate roots of polynomial equations with real coefficients

Powers and roots of complex numbers

- Using proof by mathematical induction prove de Moivre's theorem for positive integer powers:
$$(\cos\theta + i\sin\theta)^n = \cos n\theta + i\sin n\theta$$
- Prove that $(\cos\theta + i\sin\theta)^n = \cos n\theta + i\sin n\theta$ for negative integers n
- Use de Moivre's theorem to find any integer power of a given complex number

- Use de Moivre’s theorem to derive trigonometric identities
- Determine the n^{th} roots of ± 1 in polar form and their location on the unit circle
- Illustrate the geometrical relationship connecting the n^{th} roots of ± 1
- Determine the n^{th} roots of complex numbers and their location on the complex plane
- Recognise that a complex number can be represented as a vector, where the magnitude and direction of the vector are determined by the modulus and argument of the complex number respectively
- Examine and use addition and subtraction of complex numbers as vectors on the complex plane
- Examine and use the geometric interpretation of multiplying complex numbers, including rotation and dilation on the complex plane, with and without graphing applications
- Prove geometric results using complex numbers as vectors
- Solve problems and prove results using the n^{th} roots of complex numbers

Describing lines, curves and regions

- Graph vertical and horizontal lines of the form $\text{Re}(z) = c$ or $\text{Im}(z) = k$ where c and k are real constants
- Graph the line corresponding to the equation $|z - z_1| = |z - z_2|$, where z_1 and z_2 are complex numbers, and give a geometrical description of the line
- Graph the circles corresponding to the equations $|z| = r$ and $|z - z_1| = r$, where z_1 is a complex number and r is a positive real number
- Graph rays corresponding to the equations $\arg(z) = \theta$ and $\arg(z - z_1) = \theta$, where z_1 is a complex number
- Graph regions associated with lines, rays and circles defined using complex numbers, giving a geometrical description of any such curves or regions, and using circle geometry theorems where necessary

Further integration

Outcomes

A student:

- develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
- selects and uses techniques of integration to solve problems **ME2-12-04**

Content

- Derive the identities for trigonometric products as sums and differences for $\cos A \cos B = \frac{1}{2}[\cos(A-B) + \cos(A+B)]$, $\sin A \sin B = \frac{1}{2}[\cos(A-B) - \cos(A+B)]$, $\sin A \cos B = \frac{1}{2}[\sin(A+B) + \sin(A-B)]$ and $\cos A \sin B = \frac{1}{2}[\sin(A+B) - \sin(A-B)]$
- Use the identities for trigonometric products as sums and differences to solve problems and prove results
- Solve trigonometric equations by applying the formulas for trigonometric products as sums and differences for $\cos A \cos B$, $\sin A \sin B$ and $\sin A \cos B$ over restricted domains

Example(s):

Solve $\cos 3x + \cos x = 0$ for $0 \leq x \leq \pi$.

- Use identities relating the trigonometric products as sums and differences to solve problems involving integrals of the form $\int \sin(mx)\cos(nx)dx$, $\int \sin(mx)\sin(nx)dx$ or $\int \cos(mx)\cos(nx)dx$
- Derive the expressions $\sin A = \frac{2t}{1+t^2}$, $\cos A = \frac{1-t^2}{1+t^2}$ and $\tan A = \frac{2t}{1-t^2}$ where $t = \tan\frac{A}{2}$ (the t-formulas) and use them to solve trigonometric equations over restricted domains

Example(s):

Solve $3\sin\theta - 2\cos\theta = 2$ for $0 \leq \theta \leq 2\pi$ using the substitution $t = \tan\frac{\theta}{2}$.

- Find indefinite integrals and evaluate definite integrals using the method of integration by substitution, where the substitution may or may not be given
- Decompose rational functions whose denominators can be expressed as a product of distinct linear factors, distinct irreducible quadratic factors and perfect square factors into partial fractions
- Integrate rational functions whose denominators can be expressed as a product of distinct linear factors, distinct irreducible quadratic factors and perfect square factors, using partial fraction decomposition

Example(s):

Find $\int \frac{3dx}{x^2-2x}$, $\int \frac{3x+6}{x^2+4x+5}dx$ and $\int \frac{2x-5}{x^2-6x-1}dx$.

- Integrate rational functions by completing the square on a quadratic denominator

Example(s):

Find $\int \frac{dx}{x^2-2x+3}$.

- Integrate rational functions where the degree of the numerator is not less than the degree of the denominator

Example(s):

Find $\int \frac{x^2+1}{x+1}\,dx$.

- Integrate functions by changing an integrand into an appropriate form using algebraic manipulation

Example(s):

Find $\int \frac{3x+6}{x^2+4x+5}\,dx$ and $\int \frac{2x-5}{x^2-6x-1}\,dx$.

- Derive the method for integration by parts
- Find indefinite integrals and evaluate definite integrals using the method of integration by parts, including problems where more than one application is required
- Derive and use recurrence relations involving integration by parts

Example(s):

Let $I_n = \int_1^2 x^n \sqrt{x-1}\,dx$ for integers $n \geq 0$. Show that $I_n = \frac{2^{n+1}+2nI_{n-1}}{2n+3}$ for $n \geq 1$. Hence, find $\int_1^2 x^2 \sqrt{x-1}\,dx$.

- Solve theoretical problems involving multiple techniques of integration

Example(s):

Find $\int \sec^3 x \tan^3 x\,dx$.

- Solve practical problems involving multiple techniques of integration

Applications of calculus to mechanics

Outcomes

A student:

- develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
- uses mechanics to model and solve practical problems **ME2-12-05**

Content

Forces and further motion in a straight line

- Derive expressions for acceleration: $\frac{dv}{dt}$, where v is a function of t, as well as $v\frac{dv}{dx}$ and $\frac{d}{dx}\left(\frac{1}{2}v^2\right)$, where v is a function of x
- Solve problems involving velocity and acceleration expressed in terms of displacement, and acceleration expressed in terms of velocity
- Examine Newton's three laws of motion, including force, acceleration, action and reaction under a constant and non-constant force
- Find acceleration, $\ddot{x}$, using the formula $F = m\ddot{x}$, where F is the force acting on a mass, m
- Recognise that forces are vector quantities, analyse concurrent forces on a body by resolving them into perpendicular components and use vector projections to determine how much of a given force acts in a given direction in both 2D and 3D contexts

Simple harmonic motion

- Define simple harmonic motion as motion in which acceleration is proportional to, and in the opposite direction to, displacement, that is $\ddot{x} = -n^2(x-c)$, where $x-c$ is the displacement of a particle from the centre of motion at c and $\ddot{x}$ is the acceleration
- Recognise that the force $F(x)$ acting on a body of mass, m, executing simple harmonic motion according to the equation $\ddot{x} = -n^2(x-c)$, is a restoring force which acts towards the centre of motion causing the body to oscillate around the centre of motion
- Verify that $x = A\sin(nt+\alpha)+c$ is a solution to the differential equation for simple harmonic motion, equivalently expressed as $x = A\cos(nt+\beta)+c$, or $x = C\sin(nt)+D\cos(nt)+c$
- Describe simple harmonic motion using displacement, velocity, acceleration, force, amplitude and period
- Prove that motion is simple harmonic by obtaining an equation of the form $\ddot{x} = -n^2(x-c)$, when given an equation for acceleration, velocity or displacement
- Graph x, $\dot{x}$ and $\ddot{x}$ as functions of t with and without graphing applications for a particle moving in simple harmonic motion where x is of the form $x = A\cos(nt+\alpha)+c$ or $x = A\sin(nt+\alpha)+c$
- Determine equations for simple harmonic motion when given graphs of acceleration, velocity or displacement in terms of time
- Derive $v^2 = n^2[A^2-(x-c)^2]$ for a particle moving in simple harmonic motion according to $\ddot{x} = -n^2(x-c)$, where A is the amplitude
- Determine equations for the displacement, x, and velocity, v, in terms of time for an object executing simple harmonic motion according to a given equation $\ddot{x} = -n^2(x-c)$ and satisfying given initial conditions
- Model and solve problems involving simple harmonic motion using relevant formulas and graphs

Modelling motion without resistance

- Derive the equations of motion for a particle travelling, without resistance, in a straight line with constant and variable acceleration and use the equations of motion to solve problems
- Analyse and solve problems relating to motion on a smooth inclined plane by resolving forces into components
- Solve motion problems involving a single smooth pulley and a smooth inclined plane where a body hangs vertically or lies on a smooth horizontal or inclined plane

Rectilinear resisted motion

- Derive, from Newton's laws of motion, $\sum F = m\ddot{x}$, the equation for acceleration of a particle moving in a straight line and in the absence of external forces, except for a resistance oppositely directed to the motion and with a magnitude proportional to a power of the speed
- Derive an expression for velocity as a function of time of a particle moving in a straight line and in the absence of external forces, except for a resistance oppositely directed to the motion and with a magnitude proportional to a power of the speed
- Derive an expression for velocity as a function of displacement of a particle moving in a straight line and in the absence of external forces, except for a resistance oppositely directed to the motion and with a magnitude proportional to a power of the speed
- Derive an expression for displacement as a function of time of a particle moving in a straight line and in the absence of external forces, except for a resistance oppositely directed to the motion and with a magnitude proportional to a power of the speed
- Solve problems, excluding those with pulley systems, involving a particle moving in a straight line subject to a resistance oppositely directed to the motion and with a magnitude proportional to a power of the speed

Vertical resisted motion

- Derive, from Newton's laws of motion, $\sum F = m\ddot{x}$, the equation for acceleration of a particle moving vertically (upwards or downwards) in a resistive medium and under the influence of constant gravity, where the particle experiences a resistance, R, oppositely directed to the motion, whose magnitude is proportional to the first or second power of the speed
- Derive expressions for velocity both as a function of time and of displacement for vertical resisted motion under the influence of constant gravity, with a resistance, R, oppositely directed to the motion, whose magnitude is proportional to the first or second power of the speed
- Derive an expression for displacement as a function of time for vertical resisted motion under the influence of constant gravity, with a resistance, R, oppositely directed to the motion, whose magnitude is proportional to the first or second power of the speed
- Define the terminal velocity of a particle falling through a medium as the constant velocity the particle reaches when the resistance of the medium prevents further acceleration
- Determine the terminal velocity of a falling particle from its equation of motion for vertical resisted motion under the influence of constant gravity, with a resistance, R, oppositely directed to the motion, and whose magnitude is proportional to the first or second power of the speed
- Solve vertical resisted motion problems using the expressions derived for acceleration, velocity and displacement, including finding the maximum height reached by a particle projected vertically upwards and the time taken to reach this maximum height, and finding the time taken for a particle to return to the level from which it was projected and its terminal velocity

Projectiles and resisted motion

- Distinguish between the shape of the trajectory of a projectile moving under the influence of gravity and with negligible resistance and the shape of the trajectory of a projectile moving under the influence of gravity subject to resistance whose magnitude is proportional to the speed
- Establish and use the equations for acceleration for a projectile moving under the influence of gravity, projected at an angle to the horizontal, and subject to a resistance whose magnitude is proportional to the speed, to solve problems

Example(s):

Derive equations for horizontal and vertical displacement in terms of time for a projectile. The projectile is projected at an angle of θ to the horizontal and moving in a resisting medium. The magnitude of resistance is proportional to the speed and under the influence of gravity.

Assessment

Course standards

Course standards are comprised of syllabus standards and performance standards. Syllabus outcomes and content form the syllabus standards that describe what students are expected to know, understand and do. Performance standards, including the Common Grade Scale for Preliminary courses, HSC Performance Band Descriptions and Achievement Level Descriptions (for HSC courses with grades only) describe how well students have achieved in relation to syllabus standards. Performance standards are used to report student achievement on NESA credentials.

Performance Band Descriptions for Mathematics Extension 2

Stage 6 – Year 12

HSC performance band descriptions summarise the knowledge, understanding and skills typically demonstrated by students at each band level in a particular course. NESA uses these holistic descriptions to report a student's overall level of achievement in an HSC course.

Band E4

A student who performs at this level typically:

- demonstrates extensive knowledge, understanding and skills appropriate to the course
- creatively synthesises mathematical concepts, techniques and results to efficiently solve problems
- demonstrates sophisticated multi-step logic and mathematical insight to solve problems and prove results in familiar and unfamiliar situations
- constructs, analyses and applies mathematical models effectively to solve problems in a wide variety of situations
- communicates complex reasoning, justification and arguments effectively, using appropriate mathematical language, concise notation, diagrams, and algebraic and graphical techniques.

Band E3

A student who performs at this level typically:

- demonstrates thorough knowledge, understanding and skills appropriate to the course
- synthesises mathematical concepts, techniques and results to solve problems
- demonstrates complex multi-step logic to solve problems and prove results in familiar and unfamiliar situations
- constructs, analyses and applies mathematical models to solve problems in a variety of situations
- communicates reasoning and justification effectively, using appropriate mathematical language, notation, diagrams, and algebraic and graphical techniques.

Band E2

A student who performs at this level typically:

- demonstrates sound knowledge, understanding and skills appropriate to the course
- uses mathematical concepts, techniques and results to solve problems
- constructs and applies mathematical models to solve problems in a range of situations

- communicates reasoning and justification effectively, using mathematical language, notation, diagrams and graphs.

Band E1

Performance reported as Band E1 indicates that the minimum standard expected was not demonstrated.

School-based assessment

Schools are required to develop an assessment program for each Year 11 and Year 12 course. NESA provides information about the responsibilities of schools in developing assessment programs in course-specific assessment requirements and in the Assessment Certification Examination (ACE) rules and requirements.

Year 12 Mathematics Extension 2 school-based assessment

Stage 6 – Year 12

NESA requires schools to submit a school-based assessment mark for each Year 12 student who completes this course. Formal school-based assessment tasks should reflect the syllabus outcomes and content. The mark submitted by the school provides a summation of each student's achievement measured at several points throughout the course.

A school's program of school-based assessment includes both mandatory and non-mandatory elements.

See Assessment Certification Examination (ACE) rules and requirements for further information.

Assessment programs must reflect course components and weightings

The course components and component weightings for Year 12 are mandatory.

Course component	Weighting %
Knowledge and understanding of course content	50
Skills in Working mathematically	50

Schools may determine specific elements of their assessment program

Schools have authority to determine the number, type of task and the weighting allocated to an assessment task. Schools may also follow the sample assessment programs provided by NESA.

Sample assessment program

NESA's sample Year 12 formal school-based assessment program for Mathematics Extension 2 is:

- 4 assessment tasks, including:
  - a formal written examination
  - a weighting for any individual task of 10% to 40%.

Some students with disability may require adjustments in order to access assessment opportunities and demonstrate achievement of outcomes.

Formal school-based assessment in this course should focus on the Year 12 outcomes. The Year 11 course is assumed knowledge and may be assessed.

Sample assessment schedules

Stage 6 – Year 12

Sample assessment schedules and tasks are being updated to align with new ACE Rules. More information: New limit on take-home assessment tasks from Term 4 2026.

Sample assessment task notifications

Stage 6

Sample assessment schedules and tasks are being updated to align with new ACE Rules. More information: New limit on take-home assessment tasks from Term 4 2026.

Further information

Stage 6 – Year 12

- Assessment in Stage 6
- Principles of effective assessment
- Assessment in practice
- School-based assessment requirements
- Adjustments to assessment for students with disability
- Life Skills
- Assessment Certification Examination (ACE)

HSC examinations

The external HSC examination measures student achievement in a range of syllabus outcomes.

The external examination and its marking relate to the syllabus by:

- providing clear links to syllabus outcomes
- enabling students to demonstrate the levels of achievement outlined in the Performance Band Descriptions
- applying marking guidelines based on criteria that relate to the quality of the response
- aligning performance in the examination each year to the standards established for the course.

Examination questions may require students to integrate knowledge, understanding and skills developed through studying the course.

Some students with disability may be eligible for HSC exam provisions when completing the HSC examination.

The examination will be based on the Mathematics Extension 2 Year 12 course and will focus on the course outcomes. The Mathematics Advanced and Mathematics Extension 1 courses will be assumed knowledge for this examination.

Students will also be required to complete the Mathematics Extension 1 paper in addition to the Mathematics Extension 2 paper.

Mathematics Extension 2 HSC examination specifications

Stage 6 – Year 12

The examination will consist of a written paper worth 100 marks.

Time allowed: 3 hours plus 10 minutes reading time.

A reference sheet will be provided.

NESA-approved calculators may be used.

The paper will consist of two sections.

Section I (10 marks)

- There will be objective-response questions to the value of 10 marks.

Section II (90 marks)

- Questions may contain parts.
- There will be 37 to 42 items.
- At least two items will be worth 4 or 5 marks.

HSC Mathematics Extension 2 – Sample examination materials

Stage 6 – Year 12

- HSC Mathematics Extension 2 – annotated sample examination materials
- Mathematics Extension 2 – HSC reference sheet
- Sample HSC examinations: A4 guide for teachers

Further information

Stage 6 – Year 12

- Assessment in Stage 6
- Principles of effective assessment
- Assessment in practice
- School-based assessment requirements
- Adjustments to assessment for students with disability
- Life Skills
- Assessment Certification Examination (ACE)