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Mathematics and Statistics NCEA NZC Level 1
Subject Learning Outcomes for Assessment

Companion to the Mathematics and Statistics Learning Matrix

What are the Subject Learning Outcomes and how can I use them?

Subject Learning Outcomes identify the knowledge and skills that students need to be ready for assessment. Subject Learning Outcomes are informed by the Achievement Standards. They should be used in conjunction with the full suite of NCEA materials. For guidance on assessment criteria, please also refer to the Achievement Standards, Unpacking, and External Assessment Specifications or Conditions of Assessment as appropriate.

Subject Learning Outcomes do not replace any documents. This includes the External Assessment Specifications and Conditions of Assessment. All NCEA materials need to be used to fully understand the requirements of each Achievement Standard and to plan a robust teaching, learning, and assessment programme. Subject Learning Outcomes should not be used to make assessor judgments. The Achievement Standard and the Assessment Schedule for Internal Assessment Activities are used to make such judgments.

Subject Learning Outcomes, alongside other key documents, make clear to teachers what to include in their teaching and learning programmes and what student capabilities to check for, in the lead up to assessment. Each Subject Learning Outcome does not need the same amount of teaching time.

All learning should connect with students' lives in Aotearoa New Zealand and the Pacific. Teachers or students usually select the contexts. As such, contexts are not always specified in the Subject Learning Outcomes. Examples may be provided to illustrate topics and contexts, but they are not prescriptive.

Students are entitled to teaching that supports them to achieve higher levels of achievement. Subject Learning Outcomes mainly align with outcomes for the Achieved level. However, outcomes for higher levels of achievement are also included.

The knowledge and skills in the Subject Learning Outcomes are the expected learning that underpins each Achievement Standard. Students will draw on this learning during assessment. It is important to note that assessment is a sampling process so not everything that is taught will be assessed.

Achievement Standard 1.1 (91944): Explore data using a statistical enquiry process

What is being assessed	Subject Learning Outcome	Notes

Exploring data using a structured approach (a statistical enquiry process)	Students are able to:
	• explore data, which could include:
	  ○ CensusAtSchool New Zealand — TataurangaKiTeKura Aotearoa (censusatschool.org.nz)
	  ○ Kaggle: Your Machine Learning and Data Science Community (kaggle.com)
	  ○ Gapminder (gapminder.org)
	  ○ Stats NZ Tatauranga Aotearoa Homepage.
	• use a statistical inquiry process, including The Statistical Enquiry Cycle (PPDAC — Data Detective Poster (UPDATED JULY 2023!) – CensusAtSchool New Zealand)
	• communicate findings in context, for example, in a verbal presentation with supporting graphics, or a written report.
	
	For Merit, students are able to:
	• complete a statistical inquiry process – a completed process is required. This will include an introduction or purpose and a conclusion. The introduction or purpose must include the investigative statement or question, which may have been supplied by the teacher. The student may write about where the data comes from, how it was collected (which may lead to a discussion on sources of variation), why the data was collected, who will benefit from the investigation, or what they might expect to see in their findings (hypothesis thinking rather than a formal hypothesis statement). In writing a conclusion, the context must be used to answer the investigative question correctly or address the investigative statement.
		Although not required by the standard, it is likely that many schools will base investigations on The Statistical Enquiry Cycle when looking at a completed process.
		
		Students are not required to formulate their own correctly worded question or investigative statement for any levels of achievement. Teachers should ensure that students are working with well-formed questions or investigative statements. For examples of the questions or investigative statements, refer to the teacher guidance section for each internal assessment activity (Explore data using a statistical enquiry process | NCEA (education.govt.nz)).

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	For Excellence, students are able to: • incorporate contextual and statistical thinking — this needs to be shown in at least two places. These two types of thinking are likely (but not required) to be woven together. This does not mean a minimum of two separate instances of contextual thinking and two separate instances of statistical thinking, but the student work should be considered holistically. Students also need to reflect on the inquiry process that they have undertaken.	
Source of the data	Students are able to: • explain the source of the data. For primary data or data collected as part of the activity, explanation can include why the information to be collected was chosen and how it will be collected. For secondary data or existing data from a source, explanation can include where it came from and how reliable it is. • explain factors that influence the quality and reliability of the data. This may include sources of variation and how it was managed for primary data or how it may have been managed for a secondary data.	Assessment activities should be chosen carefully and allow students to access the information needed to explore the source of the data. **For primary data:** Students will need to think about how they will be collecting data. They can work as part of a group to plan how the data will be collected and to collect the data. As part of this process, they can discuss with others which sources of variation can and should, or should not, be managed as part of the collection process. **For secondary data:** Students should have ready access to how the data was collected, including the metadata. They may identify sources of variation that

		were managed, or likely managed in the collection. They may also suggest what they would have done or what could have been done. They may also explain what sources of variation may still be present in the data. There is no requirement in the standard to locate this explanation at any fixed point in the enquiry process. Explanations should be holistically looked at across the student evidence.

Relationships between 2 numeric variables	Students are able to:
	• understand and answer questions about data, which could include the following:
	  ○ How can numeric and categorical data be collected?
	  ○ What is the context of the data (including the overall context of the variables, how the data was collected, dependent and independent variables)?
	  ○ What types of variation occur in the collection of this type of data?
	  ○ How can or should (or not) this variation be managed?
	  ○ What types of visualisations support this type of data?
	  ○ What measures, including statistics, are useful for this type of data?
	  ○ What makes a good scatter graph? (y vs x in the title)
	
	• describe features of visualisations (and justify in context with measures for Merit):
	  ○ direction and strength of relationship (Direction — positive or negative based on bottom left to top right for positive or reverse for negative, quadrant count ratio. Strength — a visual indicator and comment on low, medium, or high
		Data — numeric data must be used for a relationship investigation. Continuous data is not required, but the data must contain enough natural variation within the values to allow for meaningful relationship analysis. Students may consider different sources of variation as part of the discussion on the source of the data, but this is **not** a requirement for achieving the standard.
		
		Assessment activities should be chosen carefully. They should lead to an investigation that shows a

	scattering. Examples of visual indicators include brush stroke, rectangle, cigar/sausage/oval shape, shading in/out, train tracks) ○ clusters (circling them on the graph and giving x interval and y interval for the cluster) ○ unusual or interesting data points (state the co-ordinates, could comment on vertical distance from trend line or distance from the rest of the data patterns). • consider different sources of variation in the data collection process for primary data collection, for example: ○ natural or real variation — the data needs to contain sufficient variation to allow for analysis. For example, when looking at discrete data such as age or shoe sizes, 3 or 4 response options would not produce a viable data set. ○ occasion-to-occasion variation — examples include blood pressure, speed of object, blood sugar, height, heart rate, memory tests, activity where continued practise would lead to increased ability, such as throwing a new or foreign object like a gumboot — the more you do it the better your technique becomes, so considering “how much practise” or “how many attempts” becomes a source of variation ○ measurement variation — examples include height, foot length, throwing distance, speed, reaction time, time from planting to germination, seed size ○ induced variation — examples include the consistency of conditions at the time of data collection, including wind, temperature, weight of objects thrown, and/or watering procedures.	relationship to allow students to give good evidence against the standard. When sourcing visualisations (compare with creating visualisations) students need to ensure that they will be able to read sufficient information from the graph when looking for measures, such as being reasonably able to read data points and calculate gradient and intercept of a trend line. A line of best fit (including equation) is not required to meet the standard but if included can be done so manually or digitally. Care should be taken with the scale for each axis. Formal regression analysis (explaining least squares regression or using r^2) is not required at this level. A prediction can be made using either visual inspection of the graph or substitution into the line of best fit equation.

		The exemplar marking schedules found in Teacher Guidance offer a single example of what a student may do in the lower section of the table titled “For example (description of possible student response to this activity)”. It does not define what is required for the standard, but it exemplifies what a student may do. In this case, for this exemplar, the student has decided to manually add “train tracks” to their graph. This is an example of what the student may have done. This is not a requirement for the standard.
Comparison of one numeric variable between two categories	Students are able to: • understand and answer questions about data which could include the following: ○ How can numeric and categorical data be collected? ○ What is the context of the data (including the overall context of the variables, how the data was collected, dependent and independent variables)? ○ What types of variation occur in the collection of this type of data? ○ How can or should (or not) this variation be managed? ○ Why is random sampling important? ○ What effect does sample size have? ○ What types of visualisations support this type of data? ○ What measures, including statistics, are useful for this type of data? ○ What makes a good visualisation?	When sourcing visualisations (compared with creating visualisations) students need to ensure that they will be able to read sufficient information from the graph when looking for measures, such as summary statistics. Choosing a sample — for digital or readily available data sets, samples of size 100 or 1000 are recommended.

	• describe features of visualisations (and justify in context with measures for Merit):
	  ○ centre (median, mean)
	  ○ spread (interquartile range, range)
	  ○ shape (uniform, rectangular, modality, skew)
	  ○ shift and overlap of two groups (position of the middle 50% sections through use of quartiles, ¾ - ½ rule, distance between the median as a proportion of overall visible spread, applied visually)
	  ○ clusters (location of data points given)
	  ○ unusual or interesting data points (specific values given).
	
	For Merit and Excellence:
	• make a call for a sample to population using the following information:
	  ○ the sample must be random
	  ○ in all cases, if there is no overlap between the middle 50% sections, a call can be made
	  ○ in samples of size 20-40, a call should be made using the $\frac{3}{4} - \frac{1}{2}$ rule, where clear
	  ○ in samples of size 100 or more, a call should be made visually using the distance between the medians as a proportion of overall visible spread.
	  ○ the size of the smaller group in the sample should be used as the basis for making the call.
	
	• consider different sources of variation in the data collection process, for example:
	  ○ natural or real variation — discussion of this may show up in a reflection on the process, particularly where the samples do not show a difference, there may be strong overlap with sampling variation in comparison investigations.
		A box and whisker graph is needed for all levels of achievement, and dot plots are strongly recommended. These can be supported by other visualisations, for example stem and leaf, or histogram.
		
		Summary statistics are not required by the standard for Achieved but should be included for good statistical practice. They are needed when justifying responses for Merit and Excellence.
		
		Making a call — in order to complete an enquiry process, students will need to make a sample to population inference. The process for making the call is determined by the sample size.
		
		Students may consider different sources of variation as part of the discussion on the source of the data, but this is not a requirement for achieving the standard.

	○ occasion-to-occasion variation – examples include speed or aptitude tests where practising the tasks leads to better performance, weight of an animal, body temperature. ○ measurement variation — examples include weight, cubit length, standing time, leaf width/length/weight, energy consumption, mass of any object, jumping distance. ○ induced variation — examples include consistency of the conditions at the time of data collection including type of activity undertaken to raise heart rate, oxygen saturation levels, water temperature, size of objects tested. ○ sample variation — examples include sampling method, size of sample, expected results for different samples, variation within each sample.	
Time series investigations	Students are able to: • understand and answer questions about data including the following: ○ How can data be collected over time? ○ What is the context of the data (including the time periods and the values being recorded)? ○ What types of variation occur in the collection of this type of data? ○ How can or should (or not) this variation be managed? ○ What types of visualisations support this type of data? ○ What measures, including statistics, are useful for this type of data? ○ What makes a good time series graph? • describe features of visualisations (and justify in context with measures for Merit): ○ trend of time series (direction, gradient) ○ unusual or interesting data points, spikes, or troughs (specific points given) ○ seasonality, cycles (timeframes) ○ patterns (timeframes)	When sourcing visualisations (compared with creating visualisations) students need to ensure that they will be able to read sufficient information from the graph when looking for measures, such as start-and-end points or the points needed to calculate gradient and intercept of a trend line. When using technology students can add a digital trend. Students are not required to calculate seasonal effects. Time series investigations are useful for making future forecasts. A

	• consider different sources of variation in the data collection process, for example: ○ occasion-to-occasion variation — examples include temperature during the day (determining at which point it will be measured), blood pressure, heart rate, height, weight ○ measurement variation — examples include height of pole vault, distance of javelin throw, waterflow rate, canteen food waste, city recycling levels ○ induced variation — examples include consistency of the conditions at the time of data collection including rainfall/watering levels, ambient temperature, wind assistance.	completed investigation needs to include a forecast. Forecasts could be made using a visual inspection of the graph including use of any trend line. Formal long-term trend line analysis lies outside the scope of this Achievement Standard. As part of their investigation students may reason that a forecast is not useful. For Merit, this should be with justification. For Excellence, this should be with non-trivial explanations and extended abstract thinking. Care should be taken when using student collected data. Students should have access to data for assessment that will allow them to sufficiently demonstrate all their learning. Data without a clear trend might make this difficult. Students may consider different sources of variation as part of the discussion on the source of the data, but this is not a requirement for achieving the standard.

Probability investigations	Students are able to:
	• understand and answer questions about data including the following:
	  ○ What types of experiment can be conducted to collect data?
	  ○ What is the context of the data?
	  ○ What types of variation occur in the collection of this type of data?
	  ○ How can or should (or not) this variation be managed?
	  ○ What types of visualisations support this type of data?
	  ○ What makes a good visualisation?
	  ○ What measures, including statistics, are useful for this type of data?
	
	• describe features of visualisations (and justify in context with measures for Merit):
	  ○ clusters (location of data points given)
	  ○ unusual or interesting data points (specific values given)
	  ○ centre (mean, median, mode)
	  ○ spread (interquartile range, range)
	  ○ shape (uniform, rectangular, modality, skew)
	  ○ unusual or interesting data points (specific values given)
	  ○ patterns.
		The intent of an experimental probability investigation is to conduct an experiment to collect data and describe observed probabilities in context. In some situations, with theoretical probabilities it may be appropriate to use simple simulations. Simulations could also be run with collected data where a theoretical model does not exist. An experiment using a tool with a simple outcome (dice, spinner) needs to use digital simulation to be at the right level.

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Achievement Standard 1.2 (91945): Use mathematical methods to explore problems that relate to life in Aotearoa New Zealand of the Pacific

<table>
<tr><th>What is being assessed</th><th>Subject Learning Outcome</th><th>Notes</th></tr>
<tr><td>Number</td><td>Students are able to:
• operate with more complex rates and ratios involving metric unit conversions to solve problems — examples include blood-alcohol levels, speed, heart rate, pay rates, density, scale factor or unit cost. For example, A car travels from A to B in 25 minutes at 100 kilometres per hour. How long will the trip take at 80 kilometres per hour? This can be represented as 25 x 100 = 80x.

• operate with percentages, which includes:
  ○ using percentages to solve problems — for example, expressing a ratio as a percentage
  ○ using percentages in both directions — for example, inverse percentages or finding the original amount
  ○ examples from TKI Senior Secondary guide include the following:
    ▪ which is the stronger concentration of syrup to water, 2:7 or 3:11? This can be represented as $\frac{2}{9} > \frac{3}{14}$ (the fractions represent the part to whole relationships).
    ▪ for what positive integer values of x is this inequality true, $\frac{2}{5} > \frac{6}{x}$?
    ▪ calculate GST inclusive and exclusive values
    ▪ using ratios with objects or pictures.

• operate on very large and on very small numbers using scientific notation
• operate on numbers with integer exponents, applying exponent rules excluding use of $\sqrt[n]{x^m}$.</td><td>From Conditions of Assessment:

Number:
○ Reasoning with linear proportion, including inverse percentage change or more complex rates and ratios.
○ Integer exponents or scientific form.

Linear proportion also includes the examples shown on the left.</td></tr>
<tr><td>Algebra</td><td>Students are able to
• rearrange, and use formulas (excluding the use of logarithms) — examples include:
$d = \frac{1}{2}at^2$; $A = P(1 + nr)$; $t = 2\pi\sqrt{\frac{L}{g}}$</td><td>From Conditions of Assessment:

Algebra:</td></tr>
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	• expand and simplify expressions up to two brackets — examples include: $(2x^2 - 1)(x + 7)$; $4x(x - 2) - (x - 2)$
	• factorise polynomials, including linear and quadratics where “a” is a positive integer including 1
	• form equations and inequalities from contexts — examples include expressing a taxi charge as a linear equation (flag fall and per kilometre rate) and finding the distance for a given cost. Students should be able to form equations from tables of values using differences between terms, constant first order differences for linear relations, and constant second order differences for quadratic relations. Students can use technology-based models.
	• solve using a range of techniques including technology, and geometrically interpreting solutions of:
	  ○ linear equations, including those with x on both sides, and fractions in the question and/or the solution, such as $3x + 4 = 2x - 7$
	  ○ quadratic equations where “a” may or may not be equal to 1, excluding completing the square and use of quadratic formula
	  ○ systems of two linear equations in two-dimensional space, for example using substitution, elimination, intercept of graphs
	  ○ linear inequalities, such as $3x + 6 > 6x + 12$
	  ○ graph linear, quadratic, and exponential functions from patterns, tables, and equations – for example, making connections between representations such as number patterns, spatial patterns, tables, equations, and graphs. Further examples can be found on TKI Senior Secondary guide.
	  ○ interpret features of linear, quadratic, and exponential graphs in relation to the equation or the situation including x and y intercepts, gradient, vertices, asymptotes, symmetry
	  ○ find the equations for linear and quadratic functions, including horizontal and vertical lines, from patterns, tables or graphs
		○ Manipulating and using formulae, including rearranging for a purpose.
		○ Manipulating and simplifying expressions, including expanding or factorising.
		○ Linear inequalities.
		○ Linear tables, equations, graphs, or patterns.
		○ Quadratic tables, equations, graphs, or patterns.
		○ Exponential tables, graphs, or patterns.
		○ Simultaneous linear equations with two unknowns.
		○ Optimising solutions.
		
		Finding the equation for an exponential graph is above the expected level for assessment.

	○ make links between different representations for the same model for example, connects an equation, table and graph for distance-time graphs, filling a bath, rollercoaster ride, growth of organisms, compound interest ○ make comparisons between different functions. • find optimal solutions that maximise or minimise a quantity while meeting the constraints of the situation by making lists, tables, and graphs and comparing values — examples include, area, surface area, volume, shortest routes by time or distance, or maximising profit. For example, find the dimensions of a paddock that has maximum area given a fixed perimeter, design a car park that fits the most cars and meets certain conditions, find the maximum volume of an open-topped box created from a sheet of A4 paper, design a container of minimum surface area that holds items, or maximise profit from selling concert tickets where the price of the ticket depends on the number of seats sold.	
Measurement	Students are able to: • approximate the surface area of 3D objects using pyramids, cones, spheres, and prisms consisting of more than rectangular prisms • approximate the volume of 3D objects using pyramids, cones, spheres, and prisms consisting of more than rectangular prisms, for example, design a container to hold a specified volume • convert between more complex metric units including volume, capacity, mass, and derived units, such as speed ($m.s^{-1}$ and $km.hr^{-1}$), unit costs (cents per gram and dollars per kg), fuel and energy consumption (L per 100 km, joules per minute), density ($kg.m^{-3}$ and $g.cm^{-3}$).	From Conditions of Assessment: Measurement: ○ Surface area of prisms, pyramids, cones, or spheres. ○ Volume of pyramids, cones, spheres, or composite shapes including prisms. ○ Converting between more complex metric units.
Space (Geometry)	Students are able to: • use properties of similar shapes to investigate changes in length, area, and volume of shapes with different scale factors, for example matching angles are equal, matching lengths are proportional. Here is a link for practical examples from TKI.	From Conditions of Assessment: Geometry and Space: ○ Properties of similar shapes. ○ Pythagoras' theorem in two or three dimensions.

	• explore the fixed relationships between side lengths and angles in right-angle triangles in two and three dimensions, including Pythagoras' theorem and trigonometric ratios. Here is a link to practical examples from TKI.	○ Trigonometric ratios in right-angled triangles.
Communication	Students are able to: • communicate findings in a way that a non-specialist audience can understand • follow mathematical conventions, including accuracy of rounded answers using decimal places and significant figures • use limits of accuracy to recognise the complexity of the attribute being measured or calculate • use units in all calculations, including those involving derived measures and metric conversions • link statements to the context, reflect on conjectures and provide interpretations with possible relevant explanations for observations and patterns • interpret mathematical information from a variety of worldviews or perspectives.	When communicating accurate mathematical information at achieved level, it is expected that ākonga will show how they reached their answer and indicate what their calculated answer represents. This must include correct units to be considered as evidence. For both Merit and Excellence, mathematical conventions should be followed correctly in the majority of evidence provided. Solutions should be appropriately rounded and be linked to the context of the problem. Appropriate use of technology and tools is encouraged, with students giving evidence of this usage in their submission. It is intended that students will have the opportunity to solve or explore a range of problems within a wider contextual setting. The problems need to allow scope for students to link

		processes together to be able to reach Merit and Excellence. Students should have the opportunity to explore the context before beginning their independent work. This could include brainstorming in groups or with the whole class, with kaiako support, to gain a greater understanding of the context and the broad areas of mathematics required to complete the activity. Good planning will ensure that students are able to meet the standard. Any plans written by students should be checked before independent work begins. Check Conditions of Assessment for guidance on feedback.
Problem solving	Students are able to: • formulate questions about the situations that can be investigated — for example, using "What do you notice?" and "What do you wonder?" to develop further questions for investigation or exploration. • use a range of representations including technology, models, manipulatives, drawings, symbols, equations, tables, graphs, and languages • describe and explain patterns, trends and generalisations in context • use mathematics to reach conclusions, rather than single solutions. For Merit, students are able to: • make logical connections by linking one process to another as part of a problem or problems — examples of logical connections include: linking Pythagoras' theorem to finding the volume of an object approximated by a	Each process, chosen and applied correctly, needs to come from within a different line as shown in the Conditions of Assessment. For example, students cannot receive credit for using both percentages and complex rates or ratios. Only one of these would count towards achieved. Students may use appropriate technology and resources.

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	cone, forming two or more linear graphical models and solving points of intersection, using a quadratic pattern and graph to optimise a solution, using trigonometric ratios to find the height of a triangular section on the side of a building, finding the whole surface area of a house and roof to be painted, and then calculating how much a tradesperson will need to be paid based on an average painting speed (three connected processes, each coming from a different bullet in the Conditions of Assessment: trigonometric ratios, surface area involving prisms, and more complex rates). For Excellence, students are to: • further develop (extend) at least one problem or one section from within previously chosen mathematical methods, recognising that not all problems have a singular or finite solution. They could explore one or more of the following: ○ Underlying assumptions made throughout the exploration and their mathematical impact on any solution found. ○ Mathematical explanation of limitations of models or solutions. ○ Mathematical generalisations or predictions, including recommendations or best models where appropriate.	Each part of the connection needs to be completed correctly to meet the requirement. Logically connecting three processes for two or more connections meets the requirements.

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Achievement Standard 1.3 (91946): Interpret and apply mathematical and statistical information in context

What is being assessed	Subject learning outcome
Interpret and apply information	Students are able to: • extract information from mathematical and statistical media — this includes reading text and graphics and identifying mathematical and statistical information. Examples include reading a newspaper or magazine article and finding facts and figures in text, diagrams, photographs, or infographics, reading given charts, tables, or graphs, or watching supplied media and noting relevant figures made and images used. • make an informed judgement or decision using extracted information — this includes making sense of, and interpreting, written mathematical or statistical information. Students will be able to identify the information they have extracted as either required/not required or helpful/unhelpful in helping them make a judgment or decision. In order to make an informed judgement or decision students will use information they have extracted from provided sources together with knowledge or worldviews. They should expect that they will be presented with contexts that may or may not be familiar to themselves. Examples of knowledge include information that can be found in books, podcasts, classrooms, conversations with experienced individuals, documentaries, real-life experiences, workshops, articles from reliable sources, online tutorials, and informative videos. Examples of worldviews include perspectives shaped by culture, upbringing, personal beliefs, societal norms, religious teachings, philosophical ideologies, historical events, individual experiences, scientific theories, and exposure to diverse perspectives. Making a judgement or decision may include students stating supporting information, agreeing, or disagreeing with a choice made by another person, making their own choice with supported reasons from several options, looking for and describing patterns or trends, or considering several possibilities presented.

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For Merit, students are able to:

explain variation in extracted information
explain how an informed judgement or decision was reached using information extracted from mathematical and statistical media.

Variation comes from multiple sources, including a writer or publisher’s focus, perspective or motivation, the intended audience, the difficulty or academic level of the source, the format of the information, the language or terminology used, or the technology used to produce the media. Explanations could include the reasons behind the differences within the information students are working with or why people might arrive at different judgements or decisions based on the same source of information. Students will include detail and account for judgements or decisions made, using justification.

For Excellence, students are able to:

evaluate the effects of variation in extracted information, considering assumptions and limitations
evaluate the validity of an informed judgement or decision using information extracted from mathematical and statistical media.

This may include the reliability, credibility or inherent bias in the media used, conflicts of interest, expertise levels, accuracy of the data source, or the trustworthiness and relevance of the media supplied. A “what, why, how” structure could be applied.

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Achievement Standard 1.4 (91947): Demonstrate mathematical reasoning

<table>
<tr><th>What is being assessed</th><th>Subject Learning Outcomes</th></tr>
<tr><td>Mathematical methods</td><td>Students are able to use mathematical methods relating to:

manipulate and simplify expressions, which includes:

rearranging, and using formulas (excluding the use of logarithms) – examples include:
$d = \frac{1}{2}at^2$; $A = P(1 + nr)$; $t = 2\pi\sqrt{\frac{L}{g}}$
expanding and simplifying expressions up to two brackets – examples include but not restricted to: $(2x^2 - 1)(x + 7)$, and $4x(x - 2) - (x - 2)$
factorising polynomials, including linear and quadratics where “a” (the co-efficient of x^2) is a positive integer including 1.

generalise properties of numbers and operations, which includes:

operating on algebraic fractions with numeric denominators – examples include writing the following as a single fraction: $\frac{3x-2}{5} - \frac{x-1}{3}$ or $\frac{x^2}{3} + \frac{2x^2}{4}$
operating on numbers with integer exponents, applying exponent rules excluding use of $\sqrt[n]{x^m}$ – examples include fully simplifying: $2^x \times 4^{3x-8}$.

use inequalities, which includes solving given inequalities, or forming and solving inequalities from statements
use linear and quadratic equations, which includes solving linear or quadratic equations, or forming and solving linear and quadratic equations from statements or drawings. Quadratic equations will have either a = 1 or be written in such a way that factorising is accessible for students without a graphing calculator.
use simultaneous linear equations with two unknowns, which includes solving given simultaneous equations, or forming and solving simultaneous equations. Methods for solving include substitution, elimination, graphical representation, graphing calculator and will not be prescribed. Note that solving linear with non-linear simultaneous equations are not included.
find optimal solutions that maximise or minimise a quantity while meeting the constraints of the situation by making lists, tables, and graphs and comparing values
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	• relate graphs, tables, equations, and patterns, which includes:
	  ○ graphing linear, quadratic, and exponential functions from patterns, tables, and equations, for example, making connections between representations such as number patterns, spatial patterns, tables, equations, and graphs.
	  ○ interpreting features of linear, quadratic, and exponential graphs in relation to the equation or the situation including x and y intercepts, gradient, vertex, asymptote, symmetry
	  ○ finding the equations for linear and quadratic functions, including horizontal and vertical lines, from patterns, tables or graphs
	  ○ making links between different representations for the same model, for example, connect an equation, table and graph for distance-time graphs, filling a bath, rollercoaster ride, growth of organisms, compound interest
	• relate rate of change to the gradient of a graph, which includes interpreting rates of change from contextual graphs and creating contextual graphs from descriptions
	• use Pythagoras' theorem in right-angled triangles in 2D and 3D situations
	• use trigonometric ratios in right-angled triangles in 2D and 3D situations
	• use properties of similar shapes, which includes matching angles are equal, and matching lengths are proportional
	• find surface area of prisms, pyramids, cones, and spheres, which includes approximating the surface area of 3D objects, where prisms consist of more than rectangular prisms and include cylinders
	• find volume of pyramids, cones, spheres, and composite shapes, which includes prisms includes approximating, which could include through calculation, the volume of 3D objects. Prisms include cylinders and consist of more than rectangular prisms.

Mathematical reasoning	Students are able to: • communicate the mathematical methods used to solve a problem — this could be through correctly solving a problem with limited working/evidence or showing evidence of steps taken to solve or partially solve a problem. Students should expect problems to be set in mathematical contexts for example area. For Merit, students are able to: • carry out an appropriate sequence of steps — this includes linking at least two steps, processes, or skills together to solve or partially solve a problem. For example, finding an unknown side in a triangle using trigonometric ratios and using this side to find the diagonal of a 3-D shape using Pythagoras, writing the equations for two straight lines from text and using these to find the point of intersection of two lines (using any chosen method), finding an optimal solution to a problem linking a table and a graph together.

	For Excellence, students are able to: • develop a clear chain of logical reasoning — this includes choosing from a range of methods how to approach a problem, presenting a clear path through a problem to arrive at a solution that is generally correct. It will likely include more than two steps, processes, or skills linked together. For example, finding an optimal solution to a problem linking a table, an equation, and features of a graph, or forming, rearranging, and solving for unknown constants from text, diagrams, or situations, or find an objects volume from given dimensions, increase the volume by a given percentage, then calculate how many of a different object can fit in the resulting space. • form a generalisation or provide proof, which includes showing how a solution may be obtained, showing where another piece of working has made mistakes, using given information and making links to solutions for other situations (generalisations), giving responses to a given scenario to state whether it is sometimes, always, or never true.