FORM 4

Ministry of Education
Malaysia

Integrated Curriculum for Secondary Schools
CURRICULUM SPECIFICATIONS

ADDITIONAL MATHEMATICS

Curriculum Development Centre
Ministry of Education Malaysia
2006

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First published 2006

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RUKUNEGARA

DECLARATION

OUR NATION, MALAYSIA, being dedicated

- to achieving a greater unity of all her peoples;
- to maintaining a democratic way of life;
- to creating a just society in which the wealth of the nation shall be equitably shared;
- to ensuring a liberal approach to her rich and diverse cultural traditions;
- to building a progressive society which shall be oriented to modern science and technology;

WE, her peoples, pledge our united efforts to attain these ends guided by these principles:

- BELIEF IN GOD
- LOYALTY TO KING AND COUNTRY
- UPHOLDING THE CONSTITUTION
- RULE OF LAW
- GOOD BEHAVIOUR AND MORALITY

National Philosophy of Education

Education in Malaysia is an ongoing effort towards further developing the potential of individuals in a holistic and integrated manner so as to produce individuals who are intellectually, spiritually, emotionally and physically balanced and harmonious, based on a firm belief in God. Such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards, and who are responsible and capable of achieving a high level of personal well-being as well as being able to contribute to the betterment of the family, the society and the nation at large.

PREFACE

Science and technology plays a critical role in realising Malaysia's aspiration to become a developed nation. Since mathematics is instrumental in the development of scientific and technological knowledge, the provision of quality mathematics education from an early age in the education process is thus important. The Malaysian school curriculum offers three mathematics education programs, namely Mathematics for primary schools, Mathematics and Additional Mathematics for secondary schools.

The Malaysian school mathematics curriculum aims to develop mathematical knowledge, competency and inculcate positive attitudes towards mathematics among pupils. While the Mathematics curriculum prepares pupils to cope with daily life challenges, the Additional Mathematics curriculum provides an exposure to the level of mathematics appropriate for science and technology related careers. As with other subjects in the secondary school curriculum, Additional Mathematics aims to inculcate noble values and love for the nation in the development of a holistic person, who in turn will be able to contribute to the harmony and prosperity of the nation and its people.

Additional Mathematics is an elective subject offered to the upper secondary school pupils. Beginning 2003, English is used as the medium of instruction for Science and Mathematics subjects. The policy to change the medium of instruction for the two subjects follows a phased implementation schedule and is expected to be completed by 2008. The teaching and learning of Additional Mathematics in English started in 2006.

The use of technology in the teaching and learning of Additional Mathematics is greatly emphasised. Additional Mathematics taught in English, coupled with the use of ICT, provide greater opportunities for pupils to improve their knowledge and skills in mathematics because of the richness of resources and repositories of knowledge in English. Our pupils will be able to interact with pupils from other countries, improve their proficiency in English; and thus make the learning of mathematics more interesting and exciting.

The development of this Additional Mathematics Curriculum Specifications is the work of many individuals and experts in the field. On behalf of the Curriculum Development Centre, I would like to express much gratitude and appreciation to those who have contributed in one way or another towards this initiative.

(**MAHZAN BIN BAKAR** **SMP, AMP**)

Director
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Malaysia

INTRODUCTION

A well-informed and knowledgeable society, well versed in the use of Mathematics to cope with daily life challenges is integral to realising the nation's aspiration to become an industrialised nation. Thus, efforts are taken to ensure a society that assimilates mathematics into their daily lives. Pupils are nurtured from an early age with the skills to solve problems and communicate mathematically, to enable them to make effective decisions.

Mathematics is essential in preparing a workforce capable of meeting the demands of a progressive nation. As such, this field assumes its role as the driving force behind various developments in science and technology. In line with the nation's objective to create a knowledge-based economy, the skills of Research & Development in mathematics is nurtured and developed at school level.

Additional Mathematics is an elective subject in secondary schools, which caters to the needs of pupils who are inclined towards Science and Technology. Thus, the content of the curriculum has been organised to achieve this objective.

The design of the Additional Mathematics syllabus takes into account the contents of the Mathematics curriculum. New areas of mathematics introduced in the Additional Mathematics curriculum are in keeping with new developments in Mathematics. Emphasis is placed on the heuristics of problem solving in the process of teaching and learning to enable pupils to gain the ability and confidence to use mathematics in new and different situations.

The Additional Mathematics syllabus emphasises understanding of concepts and mastery of related skills with problem solving as the main focus in the teaching and learning process. Skills of communication through mathematics are also stressed in the process of learning Additional Mathematics. When pupils explain concepts and their work, they are guided in the use of correct and precise mathematical terms and sentences. Emphasis on Mathematical communications develops pupils' ability in interpreting matters into mathematical modellings or vice versa.

The use of technology especially, Information and Communication Technology (ICT) is much encouraged in the teaching and learning process. Pupils' understanding of concepts can be enhanced as visual stimuli are provided and complex calculations are made easier with the use of calculators.

Project work, compalsory in Additional Mathematics provides opportunities for pupils to apply the knowledge and skills learned in the classroom into real-life situations. Project work carried out by pupils includes exploration of mathematical problems, which activates their minds, makes the learning of mathematics more meaningful, and enables pupils to apply mathematical concepts and skills, and further develops their communication skills.

The intrinsic values of mathematics namely thinking systematically, accurately, thoroughly, diligently and with confidence, infused throughout the teaching and learning process; contribute to the moulding of character and the inculcation of positive attitudes towards mathematics. Together with these, moral values are also introduced in context throughout the teaching and learning of mathematics.

Assessment, in the form of tests and examinations helps to gauge pupils' achievement. Assessments in Additional Mathematics include aspects such as understanding of concepts, mastery of skills and non-routine questions that demand the application of problem-solving strategies. The use of good assessment data from a variety of sources provides valuable information on

the development and progress of pupils. On-going assessment built into the daily lessons allows the identification of pupils' strengths and weaknesses, and effectiveness of the instructional activities. Information gained from responses to questions, group work results, and homework helps in improving the teaching process, and hence enables the provision of effectively aimed lessons.

AIM

The Additional Mathematics curriculum for secondary schools aims to develop pupils with in-depth mathematical knowledge and ability, so that they are able to use mathematics responsibly and effectively in communications and problem solving, and are prepared to pursue further studies and embark on science and technology related careers.

OBJECTIVES

The he Additional Mathematics curriculum enables pupils to:

1 widen their ability in the fields of number, shape and relationship as well as to gain knowledge in calculus, vector and linear programming,

2 enhance problem-solving skills,

3 develop the ability to think critically, creatively and to reason out logically,

4 make inference and reasonable generalisation from given information,

5 relate the learning of Mathematics to daily activities and careers,

6 use the knowledge and skills of Mathematics to interpret and solve real-life problems,

7 debate solutions using precise mathematical language,

8 relate mathematical ideas to the needs and activities of human beings,

9 use hardware and software to explore mathematics, and

10 practise intrinsic mathematical values.

ORGANISATION OF CONTENT

The contents of the Form Four Additional Mathematics are arranged into two learning packages. They are the Core Package and the Elective Package.

The Core Package, compulsory for all pupils, consists of nine topics arranged under five components, that is:

- Geometry
- Algebra
- Calculus
- Trigonometry
- Statistics

Each teaching component includes topics related to one branch of mathematics. Topics in a particular teaching component are arranged according to hierarchy whereby easier topics are learned earlier before proceeding to the more complex topics.

The Elective Package consists of two packages, namely the Science and Technology Application Package and the Social Science Application Package. Pupils need to choose one Elective Package according to their inclination in their future field.

The Additional Mathematics Curriculum Specifications is prepared in a format which helps teachers to teach a particular topic effectively. The contents of each topic are divided into five columns:

- Learning Objectives;
- Suggested Teaching and Learning Activities;
- Learning Outcomes;
- Points to Note; and
- Vocabulary.

All concepts and skills taught for a particular topic are arranged into a few learning units that are stated in the **Learning Objectives** column. These Learning Objectives are arranged according to hierarchy from easy to the more abstract concepts.

The **Suggested Teaching and Learning Activities** column lists some examples of teaching and learning activities including methods, techniques, strategies and resources pertaining to the specific concepts or skills. These, however, are mere sample learning experiences and are not the only activities to be used in the classrooms. Teachers are encouraged to look for further examples, determine the teaching and learning strategies most suitable for their pupils and provide appropriate teaching and learning materials. Teachers should also make cross-references to other resources such as the textbooks, and the Internet.

The **Learning Outcomes** column defines clearly what pupils should be able to do after a learning experience. The intended outcomes state the mathematical abilities that should transpire from the activities conducted. Teachers are expected to look for indicators that pupils have acquired all of the abilities stated.

In the **Points To Notes** column, attention is drawn to the more significant aspects of mathematical concepts and skills to be taught. This column consists of:

- limitations to the scope of a particular topic;
- certain emphases;
- notations; and
- formulae.

The **Vocabulary** column consists of standard mathematical terminologies, instructional words or phrases that are relevant in structuring activities, asking questions or setting task. It is important to pay careful attention to the use of correct terminologies and these needs to be systematically introduced to pupils in various contexts so as to enable pupils to understand the meanings of the terms and learn to use them appropriately.

EMPHASES IN TEACHING AND LEARNING

The teaching and learning process in this curriculum emphasise concept building and skills acquisition as well as the inculcation of good and positive values. Beside these, there are other elements that have to be taken into account and carefully planned and infused into the teaching and learning of the subject. The main elements focused in the teaching and learning of Additional Mathematics are as follows:

Problem Solving

In the Mathematics Curriculum, problem-solving skills and problem-solving strategies such as trial and improvement, drawing diagrams, tabulating data, identifying polar, experiment/simulation, solving easier problems, finding analogy and working backwards have already been learnt. Further strengthening of the above strategies must be carried out in the process of teaching and learning of Additional Mathematics. Besides routine questions,

pupils must be able to solve non-routine problems using problem-solving strategies. Teachers are also encouraged to demonstrate problems with multiple problem-solving strategies.

Communication in Mathematics

The skills of communication in mathematics are also stressed in the teaching and learning of Additional Mathematics. Communication is an essential means of sharing ideas and clarifying the understanding of mathematics. Through communication, mathematical ideas become the object of reflection, discussion and modification. Communicational skills in mathematics include reading, writing, listening and speaking. Through effective mathematical communication, pupils will become efficient in problem-solving and be able to explain their conceptual understanding and mathematical skills to their peers and teachers. Therefore, through the teaching and learning process, teachers should frequently create opportunities for pupils to read, write and discuss ideas in which the language of mathematics becomes natural and this can only be done through suitable mathematical tasks that are worthwhile topics for discussion.

Pupils who have developed the skills to communicate mathematically will become more inquisitive and, in the process, gain confidence. Emphasis on mathematical communications will develop pupils ability in interpreting certain matters into mathematical models or vice versa. The process of analytical and systematic reasoning helps pupils to reinforce and strengthen their knowledge and understanding of mathematics to a deeper level.

Reasoning

Logical Reasoning or thinking is the basis for understanding and solving mathematical problems. The development of mathematical reasoning is closely related to the intellectual and communicative development of students. Emphasis on logical thinking, during teaching and learning activities opens up pupils minds to accept mathematics as a powerful tool in the world today.

Pupils are encouraged to estimate, predict and make intelligent guesses in the process of seeking solutions. Pupils at all levels have to be trained to investigate their predictions or guesses by using concrete materials, calculators, computers, mathematical representations and others. Logical reasoning has to be absorbed in the teaching of mathematics so that pupils can recognise, construct and evaluate predictions and mathematical arguments.

Making Connections

In the teaching and learning of Additional Mathematics, opportunities for making connections must be created so that pupils can link conceptual knowledge to procedural knowledge and relate topics within mathematics and other learning areas in general.

The Additional Mathematics curriculum covers several areas of mathematics such as Geometry, Algebra, Trigonometry, Statistics and Calculus. Without connections between these areas, pupils will have to learn and memorise too many concepts and skills separately. By making connections, pupils are able to see mathematics as an integrated whole rather than a string of unconnected ideas. When mathematical ideas and the curriculum are connected to real-life within or outside the classroom, pupils will become more conscious of the importance and significance of mathematics. They will also be able to use mathematics contextually in different learning areas and in real-life situations.

The Use of Technology

The use of ICT and other technologies is encouraged in the teaching and learning of Additional Mathematics. Technologies help pupils by increasing their understanding of abstract concepts, providing visual input and making

complex calculation easier. Calculators, computers, software related to education, web sites and learning packages can further improve the pedagogy of teaching and learning of Additional Mathematics. Schools are therefore encouraged to equip teachers with appropriate and effective software. The use of software such as Geometer's Sketchpad not only helps pupils to model problems and enables them to understand certain topics better but also enables pupils to explore mathematical concepts more effectively. However, technology can't replace a teacher. Instead it should be use as an effective tool to enhance the effectiveness of teaching and learning mathematics.

APPROACHES IN TEACHING AND LEARNING

Advancement in mathematics and pedagogy of teaching mathematics demand changes to the way mathematics is taught in the classroom. Effective use of teaching resources is vital in forming the understanding of mathematical concepts. Teachers should use real or concrete materials to help pupils gain experience, construct abstract ideas, make inventions, build self-confidence, encourage independence and inculcate the spirit of cooperation. The teaching and learning materials used should contain self-diagnostic elements so that pupils know how far they have understood certain concepts and have acquired the skills.

In order to assist pupils develop positive attitudes and personalities, the mathematical values of accuracy, confidence and thinking systematically have to be infused into the teaching and learning process. Good moral values can be cultivated through suitable contexts. Learning in groups for example can help pupils develop social skills, encourage cooperation and build self-confidence. The element of patriotism should also be inculcated through the teaching and learning process in the classroom using certain topics. Brief historical anecdotes related to aspects of mathematics and famous mathematicians associated with particular learning areas are also incorporated into the curriculum. It should be presented at appropriate points where it provides pupils with a better understanding and appreciation of mathematics.

Suitable choice of teaching and learning approaches will provide stimulating learning environment that enhance effectiveness of learning mathematics. Approaches that are considered suitable include the following:

- Cooperative learning;
- Contextual learning;
- Mastery learning;
- Constructivism;
- Enquiry; and
- Exploratory.

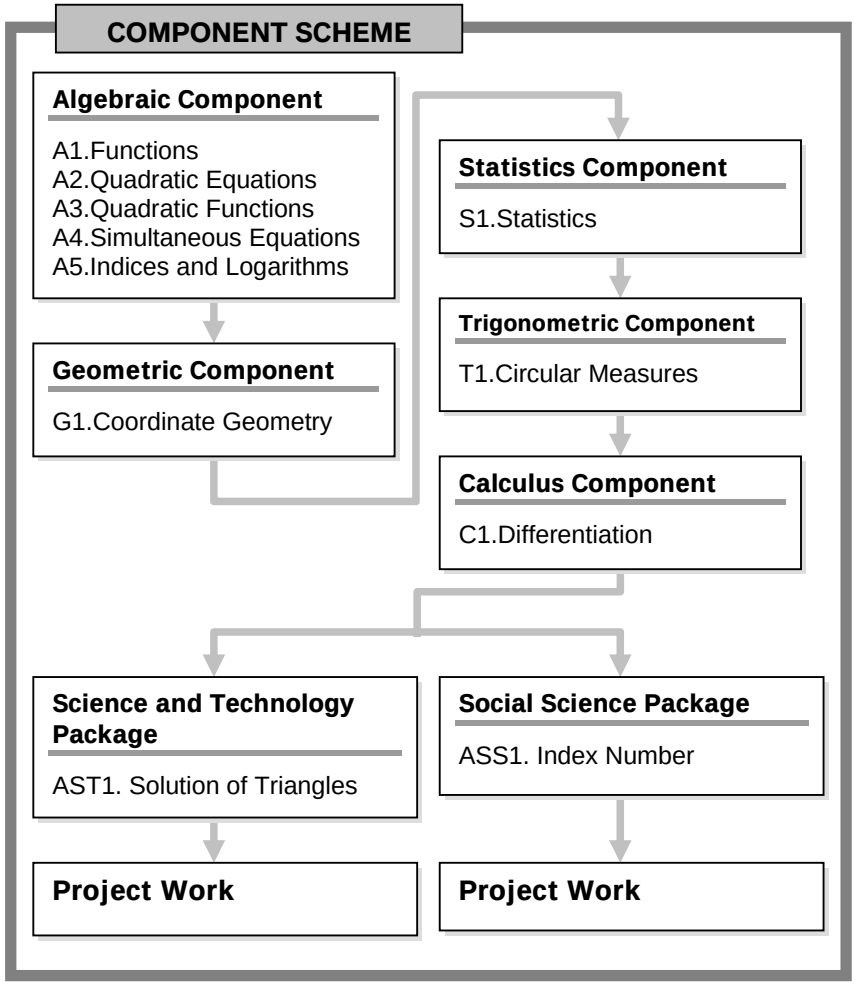
TEACHING SCHEMES

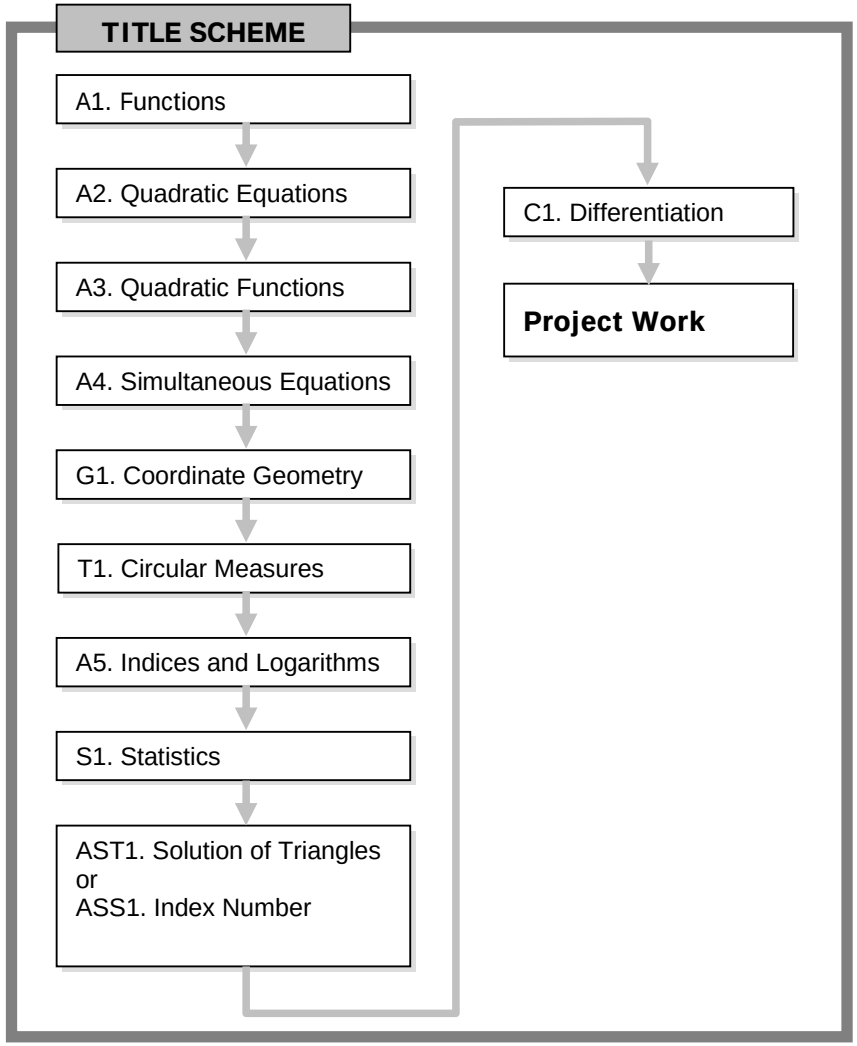
To facilitate the teaching and learning process, two types of annual schemes are suggested. They are the Component Scheme and the Title Scheme.

In the Component Scheme, all topics related to Algebra are taught first before proceeding to other components. This scheme presents the Additional Mathematics content that has been learnt before moving to new ones.

The Title Scheme on the other hands allows more flexibility for the teachers to introduce the Algebraic and Geometrical topics before introducing the new branches of Mathematics such as the Calculus.

Between these two teaching schemes, teachers are free to choose a more suitable scheme based on their pupils' previous knowledge, learning style and their own teaching style.


COMPONENT SCHEME
Algebraic Component
A1.Functions
A2.Quadratic Equations
A3.Quadratic Functions
A4.Simultaneous Equations
A5.Indices and Logarithms
Geometric Component
G1.Coordinate Geometry
Statistics Component
S1.Statistics
Trigonometric Component
T1.Circular Measures
Calculus Component
C1.Differentiation
Science and Technology Package
AST1. Solution of Triangles
Project Work
Social Science Package
ASS1. Index Number
Project Work


TITLE SCHEME
A1. Functions
A2. Quadratic Equations
A3. Quadratic Functions
A4. Simultaneous Equations
G1. Coordinate Geometry
T1. Circular Measures
A5. Indices and Logarithms
S1. Statistics
AST1. Solution of Triangles
or
ASS1. Index Number
C1. Differentiation
Project Work

PROJECT WORK

Project Work is a new element in the Additional Mathematics curriculum. It is a mean of giving pupils the opportunity to transfer the understanding of mathematical concepts and skills learnt into situations outside the classroom. Through Project Work, pupils are to pursue solutions to given tasks through activities such as questioning, discussing, debating ideas, collecting and analyzing data, investigating and also producing written report. With regards to this, suitable tasks containing non-routine problems must therefore be administered to pupils. However, in the process of seeking solutions to the tasks given, a demonstration of good reasoning and effective mathematical communication should be rewarded even more than the pupils abilities to find correct answers.

Every form four pupils taking Additional Mathematics is required to carry out a project work whereby the theme given is either based on the Science and Technology or Social Science package. Pupils however are allowed to choose any topic from the list of tasks provided. Project work can only be carried out in the second semester after pupils have mastered the first few chapters. The tasks given must therefore be based on chapters that have already been learnt and pupils are expected to complete it within the duration of three weeks. Project work can be done in groups or individually but each pupil is expected to submit an individually written report which include the following:

- title/topic;
- background or introduction;
- method/strategy/procedure;
- finding;
- discussion/solution; and
- conclusion/generalisation.

EVALUATION

Continual and varied forms of evaluation is an important part of the teaching and learning process. It not only provides feedback to pupils on their progress but also enable teachers to correct their pupils' misconceptions and weaknesses. Based on evaluation outcomes, teachers can take corrective measures such as conducting remedial or enrichment activities in order to improve pupils' performances and also strive to improve their own teaching skills. Schools should also design effective internal programs to assist pupils in improving their performances. The Additional Mathematics curriculum emphasis evaluation, which among other things must include the following aspects:

- concept understandings and mastery of skills; and
- non-routine questions (which demand the application of problem-solving strategies).

A1 LEARNING AREA: FUNCTIONS

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand the concept of relations.	Use pictures, role-play and computer software to introduce the concept of relations.	(i) Represent relations using: a) arrow diagrams, b) ordered pairs, c) graphs.	Discuss the idea of set and introduce set notation.	function relation object image range domain codomain map ordered pair arrow diagram
		(ii) Identify domain, object, image and range of a relation.		
		(iii) Classify a relation shown on a mapped diagram as: one-to-one, many-to-one, one-to-many or many-to-many relation.		
2 Understand the concept of functions.		(i) Recognise functions as a special relation.	Represent functions using arrow diagrams, ordered pairs or graphs, e.g.	
		(ii) Express functions using function notation.	$f : x \to 2x$ $f(x) = 2x$ "$f : x \to 2x$" is read as "function f maps x to $2x$". "$f(x) = 2x$" is read as "$2x$ is the image of x under the function f".	notation
		(iii) Determine domain, object, image and range of a function.	Include examples of functions that are not mathematically based.	

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
	Use graphing calculators or computer software to explore the image of functions.	(iv) Determine the image of a function given the object and vice versa.	Examples of functions include algebraic (linear and quadratic), trigonometric and absolute value. Define and sketch absolute value functions.	
3 Understand the concept of composite functions.	Use arrow diagrams or algebraic method to determine composite functions.	(i) Determine composition of two functions.	Involve algebraic functions only.	inverse mapping
		(ii) Determine the image of composite functions given the object and vice versa.	Images of composite functions include a range of values. (Limit to linear composite functions).	composite function
		(iii) Determine one of the functions in a given composite function given the other related function.		
4 Understand the concept of inverse functions.		(i) Find the object by inverse mapping given its image and function.	Limit to algebraic functions. Exclude inverse of composite functions.	
	Use sketches of graphs to show the relationship between a function and its inverse.	(ii) Determine inverse functions using algebra.		
		(iii) Determine and state the condition for existence of an inverse function.	Emphasise that inverse of a function is not necessarily a function.	

A2 LEARNING AREA: QUADRATIC EQUATIONS

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand the concept of quadratic equations and their roots.	Use graphing calculators or computer software such as the Geometer's Sketchpad and spreadsheet to explore the concept of quadratic equations.	(i) Recognise a quadratic equation and express it in general form.	.	quadratic equation general form root substitution
		(ii) Determine whether a given value is the root of a quadratic equation by: a) substitution, b) inspection.	Questions for 1.2(b) are given in the form of; a and b are numerical values.	inspection trial and improvement method
		(iii) Determine roots of quadratic equations by trial and improvement method.		
2 Understand the concept of quadratic equations.		(i) Determine the roots of a quadratic equation by: a) factorisation, b) completing the square, c) using the formula.	Discuss when $(x – p)(x – q) = 0$, hence $x – p = 0$ or $x – q = 0$. Include cases when $p = q$. Derivation of formula for 2.1c is not required.	factorisation completing the square

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(ii) Form a quadratic equation from given roots.	If $x = p$ and $x = q$ are the roots, then the quadratic equation is $(x - p)(x - q) = 0$, that is $x^2 - (p + q)x + pq = 0$. Involve the use of: $\alpha + \beta = \frac{-b}{a}$ and $\alpha\beta = \frac{c}{a}$ where α and β are roots of the quadratic equation $ax^2 + bx + c = 0$	
3 Understand and use the conditions for quadratic equations to have a) two different roots; b) two equal roots; c) no roots.		(i) Determine types of roots of quadratic equations from the value of $b^2 - 4ac$.	$b^2 - 4ac > 0$ $b^2 - 4ac = 0$ $b^2 - 4ac < 0$ Explain that "no roots" means "no real roots".	discriminant real roots
		(ii) Solve problems involving $b^2 - 4ac$ in quadratic equations to: a) find an unknown value, b) derive a relation.		

A3 LEARNING AREA: QUADRATIC FUNCTIONS

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand the concept of quadratic functions and their graphs.	Use graphing calculators or computer software such as Geometer's Sketchpad to explore the graphs of quadratic functions. Use examples of everyday situations to introduce graphs of quadratic functions.	(i) Recognise quadratic functions. (ii) Plot quadratic function graphs: a) based on given tabulated values, b) by tabulating values based on given functions. (iii) Recognise shapes of graphs of quadratic functions. (iv) Relate the position of quadratic function graphs with types of roots for $f(x)=0$.	Discuss cases where $a > 0$ and $a < 0$ for $f(x) = ax^2 + bx + c$	quadratic function tabulated values axis of symmetry parabola maximum point minimum point completing the square axis of symmetry
2 Find the maximum and minimum values of quadratic functions.	Use graphing calculators or dynamic geometry software such as Geometer's Sketchpad to explore the graphs of quadratic functions.	(i) Determine the maximum or minimum value of a quadratic function by completing the square.		

A3 LEARNING AREA: QUADRATIC FUNCTIONS

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
3 Sketch graphs of quadratic functions.	Use graphing calculators or dynamic geometry software such as the Geometer's Sketchpad to reinforce the understanding of graphs of quadratic functions.	(i) Sketch quadratic function graphs by determining the maximum or minimum point and two other points.	Emphasise the marking of maximum or minimum point and two other points on the graphs drawn or by finding the axis of symmetry and the intersection with the y-axis. Determine other points by finding the intersection with the x-axis (if it exists).	sketch intersection vertical line quadratic inequality range number line
4 Understand and use the concept of quadratic inequalities.	Use graphing calculators or dynamic geometry software such as the Geometer's Sketchpad to explore the concept of quadratic inequalities.	(i) Determine the ranges of values of x that satisfies quadratic inequalities.	Emphasise on sketching graphs and use of number lines when necessary.	

A4 LEARNING AREA: SIMULTANEOUS EQUATIONS

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Solve simultaneous equations in two unknowns: one linear equation and one non-linear equation.	Use graphing calculators or dynamic geometry software such as the Geometer's Sketchpad to explore the concept of simultaneous equations. Use examples in real-life situations such as area, perimeter and others.	(i) Solve simultaneous equations using the substitution method. (ii) Solve simultaneous equations involving real-life situations.	Limit non-linear equations up to second degree only.	simultaneous equations intersection substitution method

A5 LEARNING AREA: INDICES AND LOGARITHMS

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand and use the concept of indices and laws of indices to solve problems.	Use examples of real-life situations to introduce the concept of indices. Use computer software such as the spreadsheet to enhance the understanding of indices.	(i) Find the values of numbers given in the form of: a) integer indices, b) fractional indices. (ii) Use laws of indices to find the values of numbers in index form that are multiplied, divided or raised to a power. (iii) Use laws of indices to simplify algebraic expressions.	Discuss zero index and negative indices.	base integer indices fractional indices index form raised to a power law of indices
2 Understand and use the concept of logarithms and laws of logarithms to solve problems.	Use scientific calculators to enhance the understanding of the concept of logarithms.	(i) Express equation in index form to logarithm form and vice versa. (ii) Find logarithm of a number.	Explain definition of logarithm. $N = ax$; $\log_a N = x$ with $a > 0$, $a \neq 1$. Emphasise that: $\log_a 1 = 0$; $\log_a a = 1$. Emphasise that: a) logarithm of negative numbers is undefined; b) logarithm of zero is undefined. Discuss cases where the given number is in: a) index form, b) numerical form.	index form logarithm form logarithm undefined

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(iii) Find logarithm of numbers by using laws of logarithms.	Discuss laws of logarithms.	
		(iv) Simplify logarithmic expressions to the simplest form.		
3 Understand and use the change of base of logarithms to solve problems.		(i) Find the logarithm of a number by changing the base of the logarithm to a suitable base.	Discuss: $\log_a b = \frac{1}{\log_b a}$	
		(ii) Solve problems involving the change of base and laws of logarithms.		
4 Solve equations involving indices and logarithms.		(i) Solve equations involving indices.	Equations that involve indices and logarithms are limited to equations with single solution only. Solve equations involving indices by: a) comparison of indices and bases, b) using logarithms.	
		(ii) Solve equations involving logarithms.		

G1 LEARNING AREA: COORDINATE GEOMETRY

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Find distance between two points.	Use examples of real-life situations to find the distance between two points.	(i) Find the distance between two points using formula.	Use the Pythagoras' Theorem to find the formula for distance between two points.	distance midpoint
2 Understand the concept of division of line segments.		(i) Find the midpoint of two given points.	Limit to cases where m and n are positive. Derivation of the formula $\left(\frac{nx_1 + mx_2}{m+n}, \frac{ny_1 + my_2}{m+n}\right)$ is not required.	coordinate ratio
		(ii) Find the coordinates of a point that divides a line according to a given ratio $m : n$.		
3 Find areas of polygons.	Use dynamic geometry software such as the Geometer's Sketchpad to explore the concept of areas of polygons. Use $\frac{1}{2}\begin{vmatrix} x_1 & x_2 & x_3 & x_4 \\ y_1 & y_2 & y_3 & y_4 \end{vmatrix}$ for substitution of coordinates into the formula.	(i) Find the area of a triangle based on the area of specific geometrical shapes.	Limit to numerical values. Emphasise the relationship between the sign of the value for area obtained with the order of the vertices used.	area polygon geometrical shape quadrilateral
		(ii) Find the area of a triangle by using formula.	Derivation of the formula: $\frac{1}{2}\left(\begin{matrix} x_1y_1 + x_2y_3 + x_3y_1 - x_2y_1 \\ - x_3y_2 - x_1y_3 \end{matrix}\right)$ is not required. Emphasise that when the area of polygon is zero, the given points are collinear.	vertex vertices clockwise anticlockwise modulus collinear
		(iii) Find the area of a quadrilateral by using formula.		

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
4 Understand and use the concept of equation of a straight line.	Use dynamic geometry software such as the Geometer's Sketchpad to explore the concept of equation of a straight line.	(i) Determine the x-intercept and the y-intercept of a line.		x-intercept y-intercept gradient
		(ii) Find the gradient of a straight line that passes through two points.		
		(iii) Find the gradient of a straight line using the x-intercept and y-intercept.		
		(iv) Find the equation of a straight line given: a) gradient and one point, b) points, c) x-intercept and y-intercept.	Answers for learning outcomes 4.4(a) and 4.4(b) must be stated in the simplest form. Involve changing the equation into gradient and intercept form.	straight line general form intersection gradient form intercept form
		(v) Find the gradient and the intercepts of a straight line given the equation.		
		(vi) Change the equation of a straight line to the general form.		
		(vii) Find the point of intersection of two lines.		

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
5 Understand and use the concept of parallel and perpendicular lines.	Use examples of real-life situations to explore parallel and perpendicular lines. Use graphic calculator and dynamic geometry software such as Geometer's Sketchpad to explore the concept of parallel and perpendicular lines.	(i) Determine whether two straight lines are parallel when the gradients of both lines are known and vice versa. (ii) Find the equation of a straight line that passes through a fixed point and parallel to a given line. (iii) Determine whether two straight lines are perpendicular when the gradients of both lines are known and vice versa. (iv) Determine the equation of a straight line that passes through a fixed point and perpendicular to a given line. (v) Solve problems involving equations of straight lines.	Emphasise that for parallel lines: $m_1 = m_2$. Emphasise that for perpendicular lines $m_1 m_2 = -1$. Derivation of $m_1 m_2 = -1$ is not required.	parallel perpendicular

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
6 Understand and use the concept of equation of locus involving distance between two points.	Use examples of real-life situations to explore equation of locus involving distance between two points. Use graphing calculators and dynamic geometry software such as the Geometer's Sketchpad to explore the concept of parallel and perpendicular lines.	(i) Find the equation of locus that satisfies the condition if: a) the distance of a moving point from a fixed point is constant, b) the ratio of the distances of a moving point from two fixed points is constant. (ii) Solve problems involving loci.		equation of locus moving point loci

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand and use the concept of measures of central tendency to solve problems.	Use scientific calculators, graphing calculators and spreadsheets to explore measures of central tendency. Pupils collect data from real-life situations to investigate measures of central tendency.	(i) Calculate the mean of ungrouped data.	Discuss grouped data and ungrouped data.	measure of central tendency mean mode median ungrouped data frequency distribution table modal class
		(ii) Determine the mode of ungrouped data.		
		(iii) Determine the median of ungrouped data.		
		(iv) Determine the modal class of grouped data from frequency distribution tables.	Involve uniform class intervals only.	uniform class interval histogram
		(v) Find the mode from histograms.		
		(vi) Calculate the mean of grouped data.	Derivation of the median formula is not required.	midpoint cumulative frequency
		(vii) Calculate the median of grouped data from cumulative frequency distribution tables.		distribution table ogive
		(viii) Estimate the median of grouped data from an ogive.	Ogive is also known as cumulative frequency curve.	

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(ix) Determine the effects on mode, median and mean for a set of data when: a) each data is changed uniformly, b) extreme values exist, c) certain data is added or removed.		range interquartile measures of dispersion extreme value lower boundary
		(x) Determine the most suitable measure of central tendency for given data.	Involve grouped and ungrouped data	
2 Understand and use the concept of measures of dispersion to solve problems.		(i) Find the range of ungrouped data.		
		(ii) Find the interquartile range of ungrouped data.		
		(iii) Find the range of grouped data.		
		(iv) Find the interquartile range of grouped data from the cumulative frequency table.	Determine the upper and lower quartiles by using the first principle.	standard deviation class interval upper quartile lower quartile

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(v) Determine the interquartile range of grouped data from an ogive.		
		(vi) Determine the variance of: a) ungrouped data, b) grouped data.		variance
		(vii) Determine the standard deviation of: a) ungrouped data, b) grouped data.		
		(viii) Determine the effects on range, interquartile range, variance and standard deviation for a set of data when: a) each data is changed uniformly, b) extreme values exist, c) certain data is added or removed.		
		(ix) Compare measures of central tendency and dispersion between two sets of data.	Emphasise that comparison between two sets of data using only measures of central tendency is not sufficient.	

T1 LEARNING AREA: CIRCULAR MEASURE

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand the concept of radian.	Use dynamic geometry software such as the Geometer's Sketchpad to explore the concept of circular measure.	(i) Convert measurements in radians to degrees and vice versa.	Discuss the definition of one radian. "rad" is the abbreviation of radian. Include measurements in radians expressed in terms of π.	radian degree
2 Understand and use the concept of length of arc of a circle to solve problems.	Use examples of real-life situations to explore circular measure.	(i) Determine: a) length of arc, b) radius, c) angle subtended at the centre of a circle based on given information. (ii) Find perimeter of segments of circles. (iii) Solve problems involving lengths of arcs.		length of arc angle subtended circle perimeter segment

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
3 Understand and use the concept of area of sector of a circle to solve problems.		(i) Determine the: a) area of sector, b) radius, c) angle subtended at the centre of a circle based on given information. (ii) Find the area of segments of circles. (iii) Solve problems involving areas of sectors.		area sector

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand and use the concept of gradients of curve and differentiation.	Use graphing calculators or dynamic geometry software such as Geometer's Sketchpad to explore the concept of differentiation.	(i) Determine the value of a function when its variable approaches a certain value.	Idea of limit to a function can be illustrated using graphs. The concept of first derivative of a function is explained as a tangent to a curve and can be illustrated using graphs.	limit tangent first derivative gradient induction curve fixed point
		(ii) Find the gradient of a chord joining two points on a curve.		
		(iii) Find the first derivative of a function $y = f(x)$, as the gradient of tangent to its graph.	Limit to $y = ax^n$; a, n are constants, $n = 1, 2, 3\ldots$	
		(iv) Find the first derivative of polynomials using the first principle.	Notation of $f'(x)$ is equivalent to $\frac{dy}{dx}$ when $y = f(x)$, $f'(x)$ read as "f prime of x".	
		(v) Deduce the formula for first derivative of the function $y = f(x)$ by induction.		
2 Understand and use the concept of first derivative of polynomial functions to solve problems.		(i) Determine the first derivative of the function $y = ax^n$ using formula.		

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(ii) Determine value of the first derivative of the function $y = ax^n$ for a given value of x.		
		(iii) Determine first derivative of a function involving: a) addition, or b) subtraction of algebraic terms.		
		(iv) Determine the first derivative of a product of two polynomials.		product quotient composite function chain rule normal
		(v) Determine the first derivative of a quotient of two polynomials.		
		(vi) Determine the first derivative of composite function using chain rule.		
		(vii) Determine the gradient of tangent at a point on a curve.	Limit cases in Learning Outcomes 2.7 through 2.9 to rules introduced in 2.4 through 2.6.	
		(viii) Determine the equation of tangent at a point on a curve.		

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(ix) Determine the equation of normal at a point on a curve.		
3 Understand and use the concept of maximum and minimum values to solve problems.	Use graphing calculators or dynamic geometry software to explore the concept of maximum and minimum values.	(i) Determine coordinates of turning points of a curve.	Emphasise the use of first derivative to determine the turning points.	turning point minimum point maximum point
		(ii) Determine whether a turning point is a maximum or a minimum point.	Exclude points of inflexion.	
		(iii) Solve problems involving maximum or minimum values.	Limit problems to two variables only.	
4 Understand and use the concept of rates of change to solve problems.	Use graphing calculators with computer base ranger to explore the concept of rates of change.	(i) Determine rates of change for related quantities.	Limit problems to 3 variables only.	rates of change
5 Understand and use the concept of small changes and approximations to solve problems.		(i) Determine small changes in quantities.	Exclude cases involving percentage change.	approximation
		(ii) Determine approximate values using differentiation.		

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
6 Understand and use the concept of second derivative to solve problems.		(i) Determine the second derivative of $y = f(x)$.	Introduce $\frac{d^2y}{dx^2}$ as $\frac{d}{dx}\left[\frac{dy}{dx}\right]$ or $f'(x) = \frac{d}{dx}(f'(x))$	second derivative
		(ii) Determine whether a turning point is maximum or minimum point of a curve using the second derivative.		

AST1 LEARNING AREA: SOLUTION OF TRIANGLES

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand and use the concept of sine rule to solve problems.	Use dynamic geometry software such as the Geometer's Sketchpad to explore the sine rule.	(i) Verify sine rule.		sine rule acute-angled triangle
	Use examples of real-life situations to explore the sine rule.	(ii) Use sine rule to find unknown sides or angles of a triangle.	Include obtuse-angled triangles.	obtuse-angled triangle ambiguous
		(iii) Find the unknown sides and angles of a triangle involving ambiguous case.		
		(iv) Solve problems involving the sine rule.		
2 Understand and use the concept of cosine rule to solve problems.	Use dynamic geometry software such as the Geometer's Sketchpad to explore the cosine rule.	(i) Verify cosine rule.	Include obtuse-angled triangles	cosine rule
	Use examples of real-life situations to explore the cosine rule.	(ii) Use cosine rule to find unknown sides or angles of a triangle.		
		(iii) Solve problems involving cosine rule.		
		(iv) Solve problems involving sine and cosine rules.		

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
3 Understand and use the formula for areas of triangles to solve problems.	Use dynamic geometry software such as the Geometer's Sketchpad to explore the concept of areas of triangles.	(i) Find the areas of triangles using the formula $\frac{1}{2}ab\sin C$ or its equivalent.		
	Use examples of real-life situations to explore areas of triangles.	(ii) Solve problems involving three-dimensional objects.		three-dimensional object

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Understand and use the concept of index number to solve problems.	Use examples of real-life situations to explore index numbers.	(i) Calculate index number.	Explain index number.	index number price index quantity at base time
		(ii) Calculate price index.		quantity at specific time
		(iii) Find Q_0 or Q_1 given relevant information.	Q_0 = Quantity at base time. Q_1 = Quantity at specific time.	
2 Understand and use the concept of composite index to solve problems.	Use examples of real-life situations to explore composite index.	(i) Calculate composite index.	Explain weightage and composite index.	
		(ii) Find index number or weightage given relevant information.		
		(iii) Solve problems involving index number and composite index.		

PW1 LEARNING AREA: PROJECT WORK

Form 4

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
1 Carry out project work.	Use scientific calculators, graphing calculators or computer software to carry out project work.	(i) Define the problem/situation to be studied.	Emphasise the use of Polya's four-step problem-solving process.	conjecture systematic critical evaluation
	Pupils are allowed to carry out project work in groups but written reports must be done individually.	(ii) State relevant conjectures.	Use at least two problem-solving strategies.	mathematical reasoning justification conclusion
		(iii) Use problem-solving strategies to solve problems.		generalisation mathematical communication
	Pupils should be given opportunity to give oral presentation of their project work.	(iv) Interpret and discuss results.		rubric
		(v) Draw conclusions and/or make generalisations based on critical evaluation of results.		
		(vi) Present systematic and comprehensive written reports.	Emphasise reasoning and effective mathematical communication.	

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