FORM 5

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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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 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 Five 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 pupils. 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;
- investigation;
- Enquiry; and
- Exploratory.

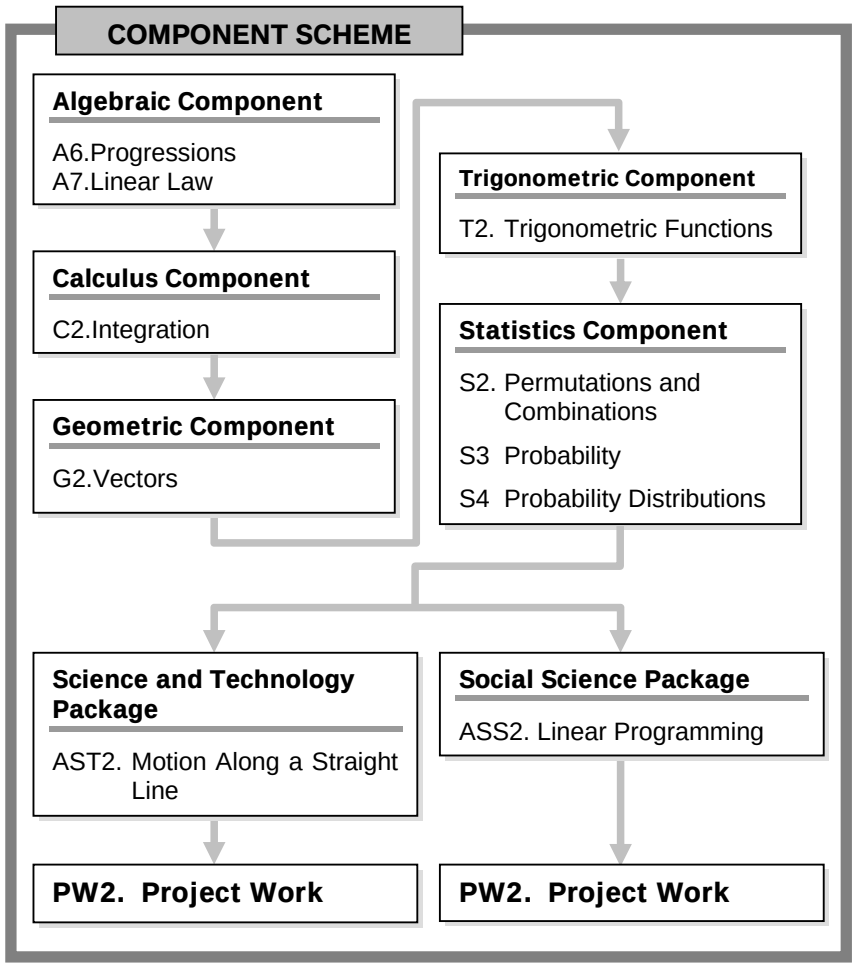
TEACHING SCHEMES

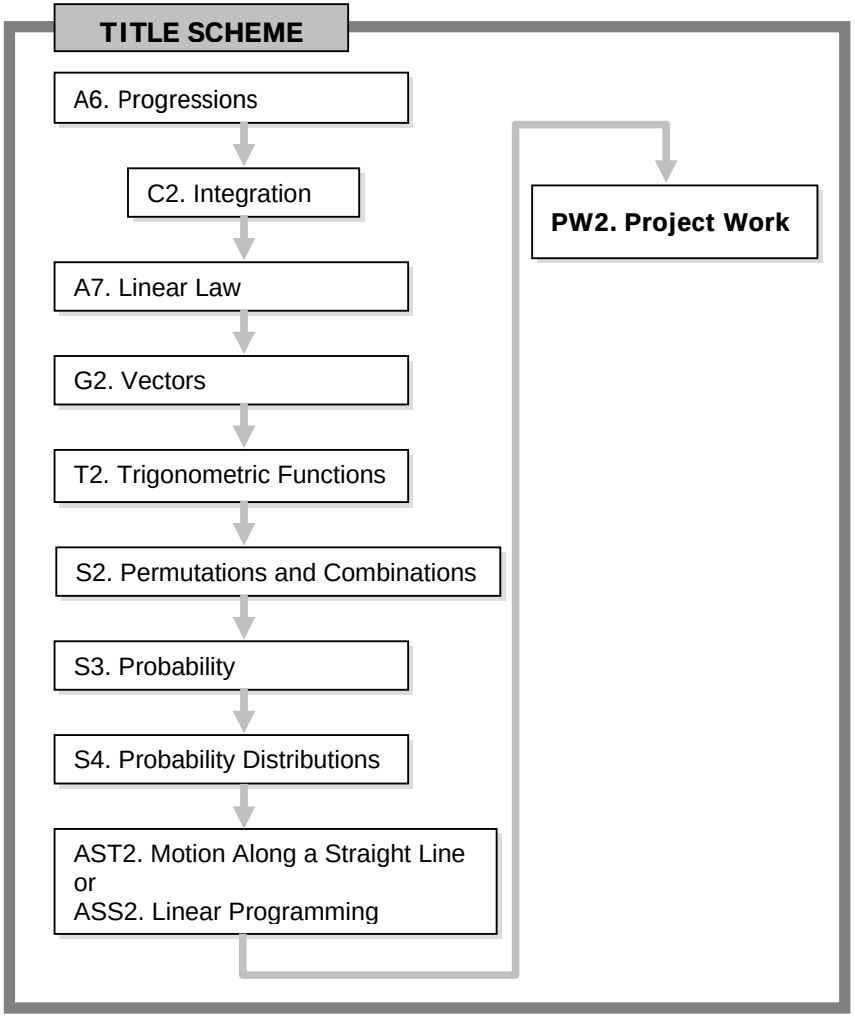
To facilitate the teaching and learning process, two types of annual schemes are suggested. They are the Component Scheme and the Title Scheme.

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
A6.Progressions
A7.Linear Law
Calculus Component
C2.Integration
Geometric Component
G2.Vectors
Trigonometric Component
T2. Trigonometric Functions
Statistics Component
S2. Permutations and Combinations
S3 Probability
S4 Probability Distributions
Science and Technology Package
AST2. Motion Along a Straight Line
PW2. Project Work
Social Science Package
ASS2. Linear Programming
PW2. Project Work


TITLE SCHEME
A6. Progressions
C2. Integration
A7. Linear Law
G2. Vectors
T2. Trigonometric Functions
S2. Permutations and Combinations
S3. Probability
S4. Probability Distributions
AST2. Motion Along a Straight Line
or
ASS2. Linear Programming
PW2. 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 five 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).

A6 LEARNING AREA: PROGRESSIONS

Form 5

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 arithmetic progression.	Use examples from real-life situations, scientific or graphing calculators and computer software to explore arithmetic progressions.	(i) Identify characteristics of arithmetic progressions. (ii) Determine whether a given sequence is an arithmetic progression. (iii) Determine by using formula: a) specific terms in arithmetic progressions, b) the number of terms in arithmetic progressions. (iv) Find: a) the sum of the first n terms of arithmetic progressions, b) the sum of a specific number of consecutive terms of arithmetic progressions, c) the value of n, given the sum of the first n terms of arithmetic progressions, (v) Solve problems involving arithmetic progressions.	Begin with sequences to introduce arithmetic and geometric progressions. Include examples in algebraic form. Include the use of the formula $T_n = S_n - S_{n-1}$ Include problems involving real-life situations.	sequence series characteristic arithmetic progression common difference specific term first term n^{th} term consecutive

A6 LEARNING AREA: PROGRESSIONS

Form 5

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
2 Understand and use the concept of geometric progression.	Use examples from real-life situations, scientific or graphing calculators; and computer software to explore geometric progressions.	(i) Identify characteristics of geometric progressions. (ii) Determine whether a given sequence is a geometric progression. (iii) Determine by using formula: a) specific terms in geometric progressions, b) the number of terms in geometric progressions. (iv) Find: a) the sum of the first n terms of geometric progressions, b) the sum of a specific number of consecutive terms of geometric progressions, c) the value of n, given the sum of the first n terms of geometric progressions,	Include examples in algebraic form.	geometric progression common ratio

A6 LEARNING AREA: PROGRESSIONS

Form 5

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(v) Find: a) the sum to infinity of geometric progressions, b) the first term or common ratio, given the sum to infinity of geometric progressions.	Discuss: As $n \to \infty$, $r^n \to 0$ then $S_\infty = \frac{a}{1-r}$ S_∞ read as "sum to infinity". Include recurring decimals. Limit to 2 recurring digits such as $0.\dot{3}$, $0.\dot{1}\dot{5}$, …	sum to infinity recurring decimal
		(vi) Solve problems involving geometric progressions.	Exclude: a) combination of arithmetic progressions and geometric progressions, b) cumulative sequences such as, (1), (2, 3), (4, 5, 6), (7, 8, 9, 10), …	

A7 LEARNING AREA: LINEAR LAW

Form 5

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 lines of best fit.	Use examples from real-life situations to introduce the concept of linear law. Use graphing calculators or computer software such as Geometer's Sketchpad to explore lines of best fit.	(i) Draw lines of best fit by inspection of given data. (ii) Write equations for lines of best fit. (iii) Determine values of variables from: a) lines of best fit, b) equations of lines of best fit.	Limit data to linear relations between two variables.	line of best fit inspection variable non-linear relation linear form reduce
2 Apply linear law to non-linear relations.		(i) Reduce non-linear relations to linear form. (ii) Determine values of constants of non-linear relations given: a) lines of best fit, b) data. (iii) Obtain information from: a) lines of best fit, b) equations of lines of best fit.		

C2 LEARNING AREA: INTEGRATION

Form 5

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 indefinite integral.	Use computer software such as Geometer's Sketchpad to explore the concept of integration.	(i) Determine integrals by reversing differentiation. (ii) Determine integrals of ax^n, where a is a constant and n is an integer, $n \neq -1$. (iii) Determine integrals of algebraic expressions. (iv) Find constants of integration, c, in indefinite integrals. (v) Determine equations of curves from functions of gradients. (vi) Determine by substitution the integrals of expressions of the form $(ax + b)^n$, where a and b are constants, n is an integer and $n \neq -1$.	Emphasise constant of integration. $\int y\,dx$ read as "integration of y with respect to x" Limit integration of $\int u^n\,dx$, where $u = ax + b$.	integration integral indefinite integral reverse constant of integration substitution

C2 LEARNING AREA: INTEGRATION

Form 5

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
2 Understand and use the concept of definite integral.	Use scientific or graphing calculators to explore the concept of definite integrals.	(i) Find definite integrals of algebraic expressions.	Include $\int_a^b kf(x)dx = k\int_a^b f(x)dx$ $\int_a^b f(x)dx = -\int_b^a f(x)dx$	definite integral limit volume region rotated revolution solid of revolution
	Use computer software and graphing calculator to explore areas under curves and the significance of positive and negative values of areas.	(ii) Find areas under curves as the limit of a sum of areas. (iii) Determine areas under curves using formula.	Derivation of formulae not required. Limit to one curve.	
	Use dynamic computer software to explore volumes of revolutions.	(iv) Find volumes of revolutions when region bounded by a curve is rotated completely about the a) x-axis, b) y-axis as the limit of a sum of volumes. (v) Determine volumes of revolutions using formula.	Derivation of formulae not required. Limit volumes of revolution about the x-axis or y-axis.	

G2 LEARNING AREA: VECTOR

Form 5

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 vector.	Use examples from real-life situations and dynamic computer software such as Geometer's Sketchpad to explore vectors.	(i) Differentiate between vector and scalar quantities. (ii) Draw and label directed line segments to represent vectors. (iii) Determine the magnitude and direction of vectors represented by directed line segments. (iv) Determine whether two vectors are equal. (v) Multiply vectors by scalars.	Use notations: Vector: $\underset{\sim}{a}$, $\overrightarrow{AB}$, **a**, **AB**. Magnitude: $\lvert\underset{\sim}{a}\rvert$, $\lvert\overrightarrow{AB}\rvert$, $\lvert\mathbf{a}\rvert$, $\lvert\mathbf{AB}\rvert$. Zero vector: $\underset{\sim}{0}$ Emphasise that a zero vector has a magnitude of zero. Emphasise negative vector: $-\overrightarrow{AB} = \overrightarrow{BA}$ Include negative scalar.	differentiate scalar vector directed line segment magnitude direction zero vector negative vector

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(vi) Determine whether two vectors are parallel.	Include: a) collinear points b) non-parallel non-zero vectors. Emphasise: If $\underset{\sim}{a}$ and $\underset{\sim}{b}$ are not parallel and $h\underset{\sim}{a} = k\underset{\sim}{b}$, then $h = k = 0$.	parallel non-parallel collinear points non-zero triangle law parallelogram law resultant vector polygon law
2 Understand and use the concept of addition and subtraction of vectors.	Use real-life situations and manipulative materials to explore addition and subtraction of vectors.	(i) Determine the resultant vector of two parallel vectors. (ii) Determine the resultant vector of two non-parallel vectors using: a) triangle law, b) parallelogram law. (iii) Determine the resultant vector of three or more vectors using the polygon law.		

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(iv) Subtract two vectors which are: a) Parallel, b) non-parallel. (v) Represent a vector as a combination of other vectors. (vi) Solve problems involving addition and subtraction of vectors.	Emphasise: $\underset{\sim}{a} - \underset{\sim}{b} = \underset{\sim}{a} + (-\underset{\sim}{b})$	
3 Understand and use vectors in the Cartesian plane.	Use computer software to explore vectors in the Cartesian plane.	(i) Express vectors in the form: a) $x\underset{\sim}{i} + y\underset{\sim}{j}$ b) $\begin{pmatrix} x \\ y \end{pmatrix}$.	Relate unit vector $\underset{\sim}{i}$ and $\underset{\sim}{j}$ to Cartesian coordinates. Emphasise: Vector $\underset{\sim}{i} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and Vector $\underset{\sim}{j} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$	Cartesian plane unit vector

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 magnitudes of vectors. (iii) Determine unit vectors in given directions. (iv) Add two or more vectors. (v) Subtract two vectors. (vi) Multiply vectors by scalars. (vii) Perform combined operations on vectors. (viii) Solve problems involving vectors.	For learning outcomes 3.2 to 3.7, all vectors are given in the form $x\underset{\sim}{i} + y\underset{\sim}{j}$ or $\begin{pmatrix} x \\ y \end{pmatrix}$. Limit combined operations to addition, subtraction and multiplication of vectors by scalars.	

T2 LEARNING AREA: TRIGONOMETRIC FUNCTIONS

Form 5

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 positive and negative angles measured in degrees and radians.	Use dynamic computer software such as Geometer's Sketchpad to explore angles in Cartesian plane.	(i) Represent in a Cartesian plane, angles greater than 360^o or 2π radians for: a) positive angles, b) negative angles.		Cartesian plane rotating ray positive angle negative angle clockwise anticlockwise unit circle quadrant reference angle trigonometric function/ratio sine cosine tangent cosecant secant cotangent special angle
2 Understand and use the six trigonometric functions of any angle.	Use dynamic computer software to explore trigonometric functions in degrees and radians. Use scientific or graphing calculators to explore trigonometric functions of any angle.	(i) Define sine, cosine and tangent of any angle in a Cartesian plane. (ii) Define cotangent, secant and cosecant of any angle in a Cartesian plane. (iii) Find values of the six trigonometric functions of any angle. (iv) Solve trigonometric equations.	Use unit circle to determine the sign of trigonometric ratios. Emphasise: $\sin\theta = \cos(90^o - \theta)$ $\cos\theta = \sin(90^o - \theta)$ $\tan\theta = \cot(90^o - \theta)$ $\text{cosec}\,\theta = \sec(90^o - \theta)$ $\sec\theta = \text{cosec}(90^o - \theta)$ $\cot\theta = \tan(90^o - \theta)$ Emphasise the use of triangles to find trigonometric ratios for special angles 30^o, 45^o and 60^o.	

T2 LEARNING AREA: TRIGONOMETRIC FUNCTIONS

Form 5

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 graphs of sine, cosine and tangent functions.	Use examples from real-life situations to introduce graphs of trigonometric functions. Use graphing calculators and dynamic computer software such as Geometer's Sketchpad to explore graphs of trigonometric functions.	(i) Draw and sketch graphs of trigonometric functions: a) $y = c + a \sin bx$, b) $y = c + a \cos bx$, c) $y = c + a \tan bx$ where a, b and c are constants and $b > 0$. (ii) Determine the number of solutions to a trigonometric equation using sketched graphs. (iii) Solve trigonometric equations using drawn graphs.	Use angles in a) degrees b) radians, in terms of π. Emphasise the characteristics of sine, cosine and tangent graphs. Include trigonometric functions involving modulus. Exclude combinations of trigonometric functions.	modulus domain range sketch draw period cycle maximum minimum asymptote

T2 LEARNING AREA: TRIGONOMETRIC FUNCTIONS

Form 5

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 basic identities.	Use scientific or graphing calculators and dynamic computer software such as Geometer's Sketchpad to explore basic identities.	(i) Prove basic identities: a) $\sin^2 A + \cos^2 A = 1$, b) $1 + \tan^2 A = \sec^2 A$, c) $1 + \cot^2 A = \operatorname{cosec}^2 A$.	Basic identities are also known as Pythagorean identities.	basic identity Pythagorean identity
		(ii) Prove trigonometric identities using basic identities.	Include learning outcomes 2.1 and 2.2.	
		(iii) Solve trigonometric equations using basic identities.		
5 Understand and use addition formulae and double-angle formulae.	Use dynamic computer software such as Geometer's Sketchpad to explore addition formulae and double-angle formulae.	(i) Prove trigonometric identities using addition formulae for $\sin (A \pm B)$, $\cos (A \pm B)$ and $\tan (A \pm B)$.	Derivation of addition formulae not required. Discuss half-angle formulae.	addition formula double-angle formula half-angle formula
		(ii) Derive double-angle formulae for $\sin 2A$, $\cos 2A$ and $\tan 2A$.		
		(iii) Prove trigonometric identities using addition formulae and/or double-angle formulae.	Exclude $a \cos x + b \sin x = c$, where $c \neq 0$.	
		(iv) Solve trigonometric equations.		

S2 LEARNING AREA: PERMUTATIONS AND COMBINATIONS — Form 5

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 permutation.			For this topic: a) Introduce the concept by using numerical examples. b) Calculators should only be used after students have understood the concept.	
	Use manipulative materials to explore multiplication rule. Use real-life situations and computer software such as spreadsheet to explore permutations.	(i) Determine the total number of ways to perform successive events using multiplication rule. (ii) Determine the number of permutations of n different objects.	Limit to 3 events. Exclude cases involving identical objects. Explain the concept of permutations by listing all possible arrangements. Include notations: a) $n! = n(n-1)(n-2)\ldots(3)(2)(1)$ b) $0! = 1$ $n!$ read as "n factorial".	multiplication rule successive events permutation factorial arrangement order

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
		(iii) Determine the number of permutations of n different objects taken r at a time. (iv) Determine the number of permutations of n different objects for given conditions. (v) Determine the number of permutations of n different objects taken r at a time for given conditions.	Exclude cases involving arrangement of objects in a circle.	
2 Understand and use the concept of combination.	Explore combinations using real-life situations and computer software.	(i) Determine the number of combinations of r objects chosen from n different objects. (ii) Determine the number of combinations r objects chosen from n different objects for given conditions.	Explain the concept of combinations by listing all possible selections. Use examples to illustrate ${}^nC_r = \frac{{}^nP_r}{r!}$	combination selection

S3 LEARNING AREA: PROBABILITY

Form 5

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 probability.	Use real-life situations to introduce probability. Use manipulative materials, computer software, and scientific or graphing calculators to explore the concept of probability.	(i) Describe the sample space of an experiment. (ii) Determine the number of outcomes of an event. (iii) Determine the probability of an event. (iv) Determine the probability of two events: a) A or B occurring, b) A and B occurring.	Use set notations. Discuss: a) classical probability (theoretical probability) b) subjective probability c) relative frequency probability (experimental probability). Emphasise: Only classical probability is used to solve problems. Emphasise: $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ using Venn diagrams.	experiment sample space event outcome equally likely probability occur classical theoretical probability subjective relative frequency experimental

S3 LEARNING AREA: PROBABILITY

Form 5

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
2 Understand and use the concept of probability of mutually exclusive events.	Use manipulative materials and graphing calculators to explore the concept of probability of mutually exclusive events. Use computer software to simulate experiments involving probability of mutually exclusive events.	(i) Determine whether two events are mutually exclusive. (ii) Determine the probability of two or more events that are mutually exclusive.	Include events that are mutually exclusive and exhaustive. Limit to three mutually exclusive events.	mutually exclusive event exhaustive independent tree diagrams
3 Understand and use the concept of probability of independent events.	Use manipulative materials and graphing calculators to explore the concept of probability of independent events. Use computer software to simulate experiments involving probability of independent events.	(i) Determine whether two events are independent. (ii) Determine the probability of two independent events. (iii) Determine the probability of three independent events.	Include tree diagrams.	

S4 LEARNING AREA: PROBABILITY DISTRIBUTIONS — Form 5

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 binomial distribution.	Use real-life situations to introduce the concept of binomial distribution. Use graphing calculators and computer software to explore binomial distribution.	(i) List all possible values of a discrete random variable. (ii) Determine the probability of an event in a binomial distribution. (iii) Plot binomial distribution graphs. (iv) Determine mean, variance and standard deviation of a binomial distribution. (v) Solve problems involving binomial distributions.	Include the characteristics of Bernoulli trials. For learning outcomes 1.2 and 1.4, derivation of formulae not required.	discrete random variable independent trial Bernoulli trials binomial distribution mean variance standard deviation

S4 LEARNING AREA: PROBABILITY DISTRIBUTIONS

Form 5

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
2 Understand and use the concept of normal distribution.	Use real-life situations and computer software such as statistical packages to explore the concept of normal distributions.	(i) Describe continuous random variables using set notations. (ii) Find probability of *z*-values for standard normal distribution. (iii) Convert random variable of normal distributions, *X*, to standardised variable, *Z*. (iv) Represent probability of an event using set notation. (v) Determine probability of an event. (vi) Solve problems involving normal distributions.	Discuss characteristics of: a) normal distribution graphs b) standard normal distribution graphs. *Z* is called standardised variable. Integration of normal distribution function to determine probability is not required.	continuous random variable normal distribution standard normal distribution *z*-value standardised variable

AST2 LEARNING AREA: MOTION ALONG A STRAIGHT LINE — Form 5

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 displacement.	Use real-life examples, graphing calculators and computer software such as Geometer's Sketchpad to explore displacement.	(i) Identify direction of displacement of a particle from a fixed point. (ii) Determine displacement of a particle from a fixed point. (iii) Determine the total distance travelled by a particle over a time interval using graphical method.	Emphasise the use of the following symbols: s = displacement v = velocity a = acceleration t = time where s, v and a are functions of time. Emphasise the difference between displacement and distance. Discuss positive, negative and zero displacements. Include the use of number line.	particle fixed point displacement distance velocity acceleration time interval

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
2 Understand and use the concept of velocity.	Use real-life examples, graphing calculators and dynamic computer software such as Geometer's Sketchpad to explore the concept of velocity.	(i) Determine velocity function of a particle by differentiation. (ii) Determine instantaneous velocity of a particle. (iii) Determine displacement of a particle from velocity function by integration.	Emphasise velocity as the rate of change of displacement. Include graphs of velocity functions. Discuss: a) uniform velocity b) zero instantaneous velocity c) positive velocity d) negative velocity.	instantaneous velocity velocity function uniform velocity rate of change maximum displacement stationary

AST2 LEARNING AREA: MOTION ALONG A STRAIGHT LINE — Form 5

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 acceleration.	Use real-life examples and computer software such as Geometer's Sketchpad to explore the concept of acceleration.	(i) Determine acceleration function of a particle by differentiation. (ii) Determine instantaneous acceleration of a particle. (iii) Determine instantaneous velocity of a particle from acceleration function by integration. (iv) Determine displacement of a particle from acceleration function by integration. (v) Solve problems involving motion along a straight line.	Emphasise acceleration as the rate of change of velocity. Discuss: a) uniform acceleration b) zero acceleration c) positive acceleration d) negative acceleration.	maximum velocity minimum velocity uniform acceleration

ASS2 LEARNING AREA: LINEAR PROGRAMMING

Form 5

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 graphs of linear inequalities.	Use real-life examples, graphing calculators and dynamic computer software such as Geometer's Sketchpad to explore linear programming.	(i) Identify and shade the region on the graph that satisfies a linear inequality. (ii) Find the linear inequality that defines a shaded region. (iii) Shade region on the graph that satisfies several linear inequalities. (iv) Find linear inequalities that define a shaded region.	Emphasise the use of solid lines and dashed lines. Limit to regions defined by a maximum of 3 linear inequalities (not including the *x*-axis and *y*-axis).	linear programming linear inequality dashed line solid line region define satisfy

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY
2 Understand and use the concept of linear programming.		(i) Solve problems related to linear programming by: a) writing linear inequalities and equations describing a situation, b) shading the region of feasible solutions, c) determining and drawing the objective function $ax + by = k$ where a, b and k are constants, d) determining graphically the optimum value of the objective function.	Optimum values refer to maximum or minimum values. Include the use of vertices to find the optimum value.	feasible solution objective function parallel lines vertex vertices optimum value maximum value minimum value

ASS2 LEARNING AREA: **LINEAR PROGRAMMING** **Form 5**

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. Pupils are allowed to carry out project work in groups but written reports must be done individually. Pupils should be given the opportunities to give oral presentations of their project work.	(i) Define the problem/situation to be studied. (ii) State relevant conjectures. (iii) Use problem-solving strategies to solve problems. (iv) Interpret and discuss results. (v) Draw conclusions and/or generalisations based on critical evaluation of results. (vi) Present systematic and comprehensive written reports.	Emphasise the use of Polya's four-step problem-solving process. Use at least two problem-solving strategies. Emphasise reasoning and effective mathematical communication.	conjecture systematic critical evaluation mathematical reasoning justification conclusion generalisation mathematical communication rubric

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PW2 LEARNING AREA: **PROJECT WORK** **Form 5**

LEARNING OBJECTIVES *Pupils will be taught to…*	SUGGESTED TEACHING AND LEARNING ACTIVITIES	LEARNING OUTCOMES *Pupils will be able to…*	POINTS TO NOTE	VOCABULARY

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