INTERNATIONAL BACCALAUREATE ORGANISATION

MIDDLE YEARS PROGRAMME

MATHEMATICS

Middle Years Programme Mathematics
August 2000

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Foreword

This Middle Years Programme mathematics guide, published in August 2000, replaces *IBMYP Mathematics Edn. 1.1* published in January 1995. Although the basic philosophy of the MYP remains unchanged, this new edition of the guide contains important changes and additions. All MYP mathematics teachers must be made aware of these changes.

Authorized MYP schools should start using this guide from September 2000 or from January 2001, depending on the start of their school year.

Contents

The Middle Years Programme

Introduction to the MYP

The Middle Years Programme (MYP) of the International Baccalaureate Organisation (IBO) is a course of study designed to meet the educational requirements of students aged between 11 and 16 years. The curriculum may be taught as an entity in itself, yet is flexible enough to allow the demands of national, regional or local legislation to be met.

The eight **subject groups** of the MYP provide a broad, traditional foundation of knowledge, while the pedagogical devices used to impart such knowledge aim to increase the students' awareness of the relationships between subjects. Students are encouraged to question and evaluate information critically, to seek out and explore the links between subjects, and to develop an awareness of their own place in the world.

Fundamental Concepts

Adolescents are confronted with a vast and often bewildering array of choices. The MYP is designed to provide students with the values and opportunities that will enable them to develop sound judgment. Learning how to learn and how to evaluate information critically is as important as the content of the disciplines themselves.

While insisting on the thorough study of the various academic subjects, the MYP also accentuates their interrelatedness and encourages a **holistic** view of knowledge. In keeping with the IBO's principles, the MYP fosters **intercultural awareness** to promote better understanding of and respect for other cultures as well as concern for international issues. The MYP also stresses the importance of **communication** through a command of one's own language, foreign language acquisition, and the appreciation of different modes of thinking and expression.

Areas of Interaction

Students are required to explore and experience the five **areas of interaction**:

- **approaches to learning (ATL)**
- **community service**
- **health and social education**
- **environment**
- ***homo faber***.

The areas of interaction should be taught through the medium of the subjects, thereby fulfilling their integrative function. Some aspects, however, may also be taught as separate courses and projects throughout the MYP where local circumstances dictate. The areas of interaction should not be taught as discrete extra subjects which would increase the student's overall workload. Student participation in the areas of interaction culminates in the **personal project**.

Curricular Framework

The MYP offers a curricular framework which allows school-specific requirements to be met while maintaining the mission and philosophy of the IBO. To ensure this, the IBO prescribes the aims and objectives of all subject groups and the personal project.

Aims and Objectives

The objectives of each subject group are skills-based and broad enough to allow for a variety of teaching and learning approaches. The choice and organization of precise content is left to schools in order to preserve flexibility. In some subjects the content is not specified while in others a framework of concepts or topics is prescribed for all MYP students to address over the five years. Such prescription is kept to a minimum and schools are asked to expand their scope of topics and depth of treatment according to their individual needs and preferences.

The aims and objectives of the subject groups address all dimensions of learning including knowledge, understanding, application and attitude.

- **Knowledge**: the facts that the student should be able to recall to ensure competence in the subject
- **Understanding**: how the student will be able to interpret or predict aspects of the subject
- **Application**: how the student will be able to apply what has been learnt in new situations
- **Attitude**: how the student is changed by the learning experience

Objectives provided by the IBO for subjects in the MYP are defined as final objectives. While teachers will find it necessary to develop their own interim objectives and assessment practices in years 1–5, the **MYP final objectives** form the basis for the **MYP assessment criteria** devised for use in the **final assessment** of students' work at the end of year 5. Whether or not schools request IBO-validated grades for their students, they are all required to organize learning and assessment in a way which is consistent with the prescribed objectives.

Schemes of Work

It is each school's responsibility to produce schemes of work which enable students to reach the objectives of each subject. Sample schemes of work or sample activities for all subject groups have been written by practising teachers as a suggested means of achieving this. MYP teachers may choose to adopt the samples offered, amend them to suit their own requirements, or write an alternative scheme of work.

Whichever schemes of work schools adopt, the MYP final objectives are prescribed. The areas of interaction should remain an integral part of the subject teaching and learning process, and must be at the core of the personal project.

Assessment

Teachers must use the assessment criteria published in this guide to assess students' work internally. All MYP schools must use these criteria for final assessment.

> Schools which request **IBO-validated grades** and **MYP certification** for students must submit internally assessed work to IBCA for external moderation.

Programme Evaluation

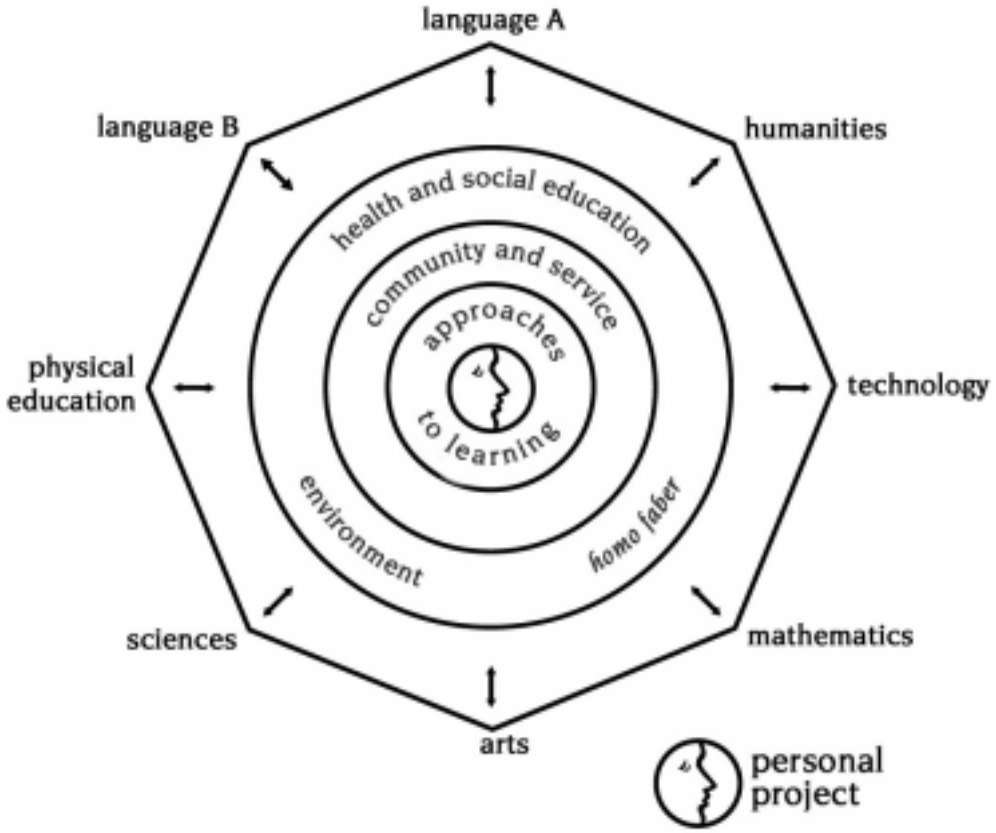
Programme evaluation is mandatory for all schools. It is a means of ensuring quality of programmes in participating schools, while assisting schools in their own self-evaluation and curriculum development procedures. Evaluation occurs at regular, pre-determined intervals (normally three years after the date of authorization to teach the programme, then every five years thereafter).

Acknowledgments

This guide has been written by practising teachers from authorized MYP schools in many regions and the MYP curriculum team at IBCA. Thanks are due to all who contributed to its completion.

Teacher support material, published separately, includes examples of practice in various MYP schools and samples of students' work assessed against the published criteria.

Curriculum Model



This diagram represents the curriculum model of the MYP. The five areas of interaction connect the development of the individual (at the centre) with the educational experience in all subject groups (on the corners of the polygon). These interactive areas are common to all disciplines with each subject developing general and specific aspects of the areas. The subject groups are also linked by the areas of interaction, thus exemplifying the interdisciplinary potential of the MYP. The five areas of interaction have no clear boundaries, but merge to form a context for learning that contributes to the student's experience of the curriculum.

MYP Mathematics

Introduction to MYP Mathematics

MYP mathematics aims to give students an appreciation of the usefulness, power and beauty of the subject. The language of mathematics enables people to model events and situations, and provides a key to understanding the world in which we live. A study of mathematics also provides the opportunity to study the language of mathematics for its own sake.

With the rapid pace of technological development, it is difficult to foresee the mathematical knowledge that students will need during their lifetime. Therefore, it is essential that students are equipped with a solid base of mathematical knowledge, related skills and attitudes to enable them to adapt as their needs arise.

Mathematics and the Fundamental Concepts of the MYP

Holistic Learning

Students will be required to use mathematics and mathematical skills in many aspects of their lives. Their knowledge and understanding of these concepts will be required for personal decision making, and participation in civic and cultural affairs.

Many of the skills learned in MYP mathematics are applied in other MYP subject groups. Thus, teachers of MYP mathematics should actively seek opportunities to link mathematical skills to teaching and learning in the other MYP subject groups. For example, science teachers will teach mathematical concepts such as graphical representation and skills such as graph construction. In order to establish such links with other subjects, teachers are advised to share the aims and objectives of mathematics with their colleagues.

The holistic approach implies the need:

- for MYP mathematics teachers to work closely with their colleagues both within the mathematics department and with other departments
- to ensure coordination and integration of subject matter across other subjects
- to encourage a reflective approach to learning.

Intercultural Awareness

MYP mathematics promotes an understanding of how cultural, societal and historical influences from a variety of cultures have influenced mathematical thought, and brought about its evolution. Students should be able to understand and discuss the international nature of mathematics.

MYP mathematics encourages an awareness of:

- how different cultures through history have counted and recorded numbers
- patterns and motifs of cultures
- how cultural forces lead to developments in mathematics, eg how the west European desire to possess land led to further developments in geometry and trigonometry through surveying and navigation
- cultural views of chance and probability.

Communication

MYP mathematics places considerable emphasis on mathematical literacy and requires students to use the language and symbols of mathematics through a variety of media and technologies. Students should come to realize that the language of mathematics is universal.

MYP mathematics teachers should:

- provide students with opportunities to communicate mathematics individually or as part of a group
- encourage students to use information and communication technologies when investigating mathematical problems.

Requirements

In the MYP, mathematics must be part of each student's experience every year. This experience will vary from school to school, and may even vary from student group to student group within the same school, depending on individual needs. The MYP allows great flexibility in the way courses are organized by schools, in the time allocation to courses in any given year, as well as in the articulation and assessment of learning from one year to the next. However, a common framework for MYP mathematics is given from which schools are expected to develop mathematics courses to suit their local requirements and preferences. The sample schemes of work give examples of how this could be achieved.

Prescribed Framework

Schools are required to develop schemes of work which follow the framework for MYP mathematics, as described in this guide. The framework prescribes a study of the following five branches of mathematics over the five years of the programme:

- **number**
- **algebra**
- **geometry and trigonometry**
- **statistics and probability**
- **discrete mathematics**.

This is not meant to be a sequence in which these branches should be taught. The framework simply outlines concepts and skills which exemplify MYP mathematics.

Rationale for the Framework

The framework aims to offer schools the possibility of organizing their own curriculum in a way which reflects local needs (including, in many cases, the requirements of national systems) while providing adequate direction and advice to ensure some commonality.

Flexibility for Schools

The five branches listed do not necessarily include all the concepts and skills of mathematics which should be addressed over the five years of the programme. Although the branches themselves are prescribed they are not intended to be the complete mathematics curriculum. They form part of a school's schemes of work together with other concepts and skills to meet local needs and/or national requirements.

Links Between the Branches of Mathematics

Concepts and skills which exemplify the prescribed branches of mathematics are often interrelated. In any particular unit of study, aspects of different branches may be present in varying degrees. The branches themselves, and the concepts and skills listed within them, are therefore not meant to be addressed in linear fashion. Schemes of work should reflect a balance of the branches over the five years.

Levels of Mathematics

Schools should structure their courses so that all MYP students have the opportunity to reach their full potential and achieve the subject group objectives. The framework for MYP mathematics is organized so that students can work at two different levels of ability: mathematics and extended mathematics.

High-ability students who are likely to gain the highest grades in mathematics should have the opportunity to develop skills and understand concepts of extended mathematics. This extended level implies a thorough grounding in the concepts and skills of the mathematics level and should not be taught as a course in itself. Although the schemes of work developed by a school must allow all students the opportunities to reach their full potential in the study of mathematics, the decision to expose individual students to work at the extended mathematics level is best left to the professional judgment of the teacher.

For schools which request **IBO-validated grades**, a decision will need to be made on the level for which each student is registered. Each student must be registered for **either** mathematics **or** extended mathematics.

Addressing the Areas of Interaction

There are five areas of interaction:

- **approaches to learning (ATL)**
- **community service**
- **health and social education**
- **environment**
- ***homo faber***.

These areas provide a means of broadening student experience, placing learning in context and helping students to develop attitudes and values based on knowledge and skills.

The areas of interaction form the basis of the MYP and contribute to an education resulting in global awareness, international understanding and an appreciation of cultural diversity. They should be at the core of the teaching of all subject groups.

Teachers should consult the guide *Areas of Interaction* to become familiar with the aims, objectives and dimensions of each area, and to help them identify links to relevant topics and issues.

Approaches to Learning

This area concerns the development of effective study skills; critical, coherent and independent thought; and the capacity for solving problems and making decisions. A study of mathematics provides opportunities for students to engage in intellectually rigorous activities promoting the development of these skills, thought processes and capacities.

Whether working independently or cooperatively, students should be given the opportunities to develop mathematical skills, organize their work effectively and use a variety of media and technologies to collect, collate and present data.

- Mathematics promotes a way of thinking which is reflected in the way that work is presented. The branch of discrete mathematics offers ways of presenting systems in a variety of forms.
- Teachers may wish their students to explore the historical aspects of mathematics to give them opportunities to explore cultural differences in mathematical thinking.
- In problem-solving exercises, there may be opportunities to share and discuss the variety of approaches taken and solutions found by students. This could lead to awareness of and a respect for different ways of thinking.
- A study of mathematics also requires students to develop a positive attitude to discovering and learning; one of the many challenges to the mathematics teacher is to support the student to this end.

Community Service

Community service helps students to look beyond the classroom, and encourages responsible and caring participation in their local setting and in the wider world.

The study of mathematics gives students opportunities to raise awareness and to take action on a variety of issues. For example students could identify an issue of importance to the community; collect, collate and present data on the issue and suggest, or even carry out, corrective action. Examples of such issues include assessing traffic flow around the school, auditing the accounts of the school shop and providing information for consumers by taking on a watchdog role. Students should be encouraged to take an active role in their school community. For example older students could tutor younger ones, or more proficient language B students could help others by developing and publishing a translation dictionary of mathematical terms.

Health and Social Education

Health and social education encourages a respect for the body and mind which in turn enables the individual to make informed, responsible choices. Mathematical knowledge and enquiry are fundamental to the understanding of such information.

- With increased data becoming available on a huge range of health-related issues such as diets and social issues such as population growth, a study of the appropriateness of statistics and probability could be undertaken, linking with *homo faber*.
- Other branches such as number and geometry and trigonometry offer opportunities for students to carry out health-related measurements on issues such as living space and comparisons of growth rates.
- Students could work on the association between mental health and time management, linking with approaches to learning.
- Pattern recognition, from a study of algebra, is a necessary skill in making sense of data and being able to make informed decisions.
- Discrete mathematics provides students with different forms of representation to illustrate ideas, issues and data.

Environment

Environment stresses the importance of conservation and challenges the student to accept responsibility for maintaining and improving a natural world for present and future generations. Through mathematical research and analysing data from their own investigations and those of others, students could examine the environmental impact of a particular development that has been made, and suggest action to rectify any problems.

Opportunities may exist to involve students in managing their own local environment, either in school or at home. Practical work in geometry and trigonometry may involve students in projects such as town planning, designing and making models of real or imagined buildings, or other space management applications. Teachers may also wish to explore the historical issues of the application of geometry such as the “Golden Ratio” used in the construction of some ancient buildings.

Homo Faber

The purpose of *homo faber* is to develop opportunities for the student to appreciate the human capacity to invent, create, transform, enjoy and improve the quality of life. *Homo faber* stresses the ways humans can initiate change and explores the consequences.

Some see mathematics as a cornerstone of philosophy, and the teaching of mathematics offers opportunities for teachers to include a study of the history of the subject and the philosophers who have contributed to the development of mathematical thought throughout history. Addressing the fundamental concept of intercultural awareness, mathematics courses could challenge students to research different number systems and ways of writing and counting numbers. Projects such as those which seek the links between geometry and art, or investigations into the shapes and motifs of different cultures, could be used to address *homo faber* as an interdisciplinary theme. Students should also be aware of the power of mathematics to mislead, criticize and destroy.

Points to Consider

- References to the areas of interaction must be natural. Teachers should avoid contrived links which do little to further the students' understanding of the issues.
- As in other areas of teaching, links to the areas of interaction must be well coordinated to avoid overstressing some aspects while neglecting others. The role of areas of interaction leaders is important. They cross departmental lines within the school and help form a global picture of the students' experience across MYP subject groups.

Aims and Objectives

Aims

The aims of any MYP subject and of the personal project state in a general way what the teacher may expect to teach or do and what the student may expect to experience or learn. In addition they suggest the ways in which the student may be changed by the learning experience.

The aims for MYP mathematics are to enable students to:

- develop a positive attitude toward the continued learning of mathematics
- appreciate the usefulness, power and beauty of mathematics, and recognize its relationship with other disciplines and with everyday life
- appreciate the international dimensions of mathematics and its varied cultural and historical perspectives
- gain knowledge and develop understanding of mathematical concepts
- develop mathematical skills and apply them
- develop the ability to communicate mathematics with appropriate symbols and language
- develop the ability to reflect upon and evaluate the significance of their work and the work of others
- develop patience and persistence when solving problems
- develop and apply information and communication technology skills in the study of mathematics.

Objectives

The objectives of any MYP subject and of the personal project state the specific targets set for learning in the subject.

The following objectives for mathematics relate directly to the assessment criteria A–D.

A Knowledge and Understanding

At the end of the course students should:

- know and understand concepts, and demonstrate skills, from the five branches of mathematics (number, algebra, statistics and probability, geometry and trigonometry, and discrete mathematics)
- be able to understand and use a variety of mathematical forms and should have the ability to move confidently between them.

B Application and Reasoning

At the end of the course students should be able to:

- select and use appropriate mathematical knowledge when investigating problems
- select and apply appropriate mathematical skills and techniques when investigating problems
- recognize patterns and structures and describe them as relationships or general rules when investigating problems
- draw conclusions consistent with findings
- justify mathematical relationships when investigating problems.

C Communication

At the end of the course, students should be able to communicate mathematical facts, ideas, methods, results and conclusions using:

- appropriate language and symbols
- a variety of media and technologies.

D Reflection and Evaluation

At the end of the course students should be able to:

- reflect on their methods and processes
- consider possible alternative approaches
- evaluate the significance and reliability of their findings and the findings of others.

Framework for Mathematics

The prescribed framework for MYP mathematics outlines **five** branches of mathematical study. These branches are:

- **number**
- **algebra**
- **geometry and trigonometry**
- **statistics and probability**
- **discrete mathematics**.

Schools must structure their schemes of work to address all five branches over the five years of the programme.

The following pages outline concepts and skills in each branch which exemplify the levels of **mathematics** and **extended mathematics**.

Number

Numeracy is an essential skill. A numerate individual has an understanding of number concepts and the skills of estimation and calculation.

Students should understand that numeracy is a form of communication which has developed since humankind's earliest beginnings, and that the evolution of mathematics is multicultural.

Number Concepts

Level	Concepts
Mathematics	• Forms of numbers (eg numerals, decimals, standard form) • Ordinality • Cardinality • Divisibility • Pattern • Number sets • Magnitude
Extended mathematics	• Irrationals • Sequences and higher-level number sets • Surd form (rationals) • Logarithms

Number Skills

Level	Skills
Mathematics	• Performing basic operations • Estimating • Approximating • Evaluating • Renaming • Classifying • Apportioning • Performing and discussing problem-solving strategies • Communicating and reasoning orally and in writing • Writing and solving problems involving the concepts at this level
Extended mathematics	• Performing higher-level operations (other binary operations, powers and roots with degree equal to or greater than 3) • Performing and discussing higher-level problem-solving strategies • Communicating and reasoning orally and in writing using mathematical language and conventions • Writing and solving problems involving the concepts at this level

Algebra

An understanding of pattern recognition is fundamental to further learning in mathematics. Students who wish to continue studying mathematics beyond MYP will require a knowledge of algebraic concepts and skills.

Teachers should, where appropriate, assist students' understanding of algebra by applying skills and reviewing concepts in practical and everyday situations.

Algebra Concepts

Level	Concepts
Mathematics	• Pronumerals and variables • Relations, functions and their graphical representations • Expressions • Equations • Coordinate systems • Repeated addition as multiplication • Repeated multiplication as indices • Inequations • Sequences—recursive and generating rules
Extended mathematics	• Coordinates—systems in three dimensions • Matrices • Logarithms • Higher-level relations, functions and their graphical representations—exponential, logarithmic, circles, rational

Algebra Skills

Level	Skills
Mathematics	• Expanding—linear and quadratic • Factorizing—linear and quadratic • Simplifying • Substituting • Solving equations—linear, simple quadratic, simultaneous—by a variety of methods including the use of graphing calculators • Sketching and interpreting graphs • Performing and discussing problem-solving strategies • Communicating and reasoning orally and in writing • Writing and solving problems involving the concepts at this level
Extended mathematics	• Solving higher-level equations including more difficult quadratics and simultaneous equations • Manipulating rational and logarithmic expressions • Performing and discussing higher-level problem-solving strategies • Communicating and reasoning orally and in writing using mathematical language and conventions • Writing and solving problems involving the concepts at this level

Geometry and Trigonometry

The study of geometry and trigonometry enhances spatial awareness and gives insights into the realms of construction and navigation. Teachers and students should not limit their study to Euclidean geometry but should be familiar with other geometries such as:

- transformation geometry—cultural and social use and its appearance in nature
- fractal geometry—iterative constructions
- non-Euclidean geometry—global navigation and topology and its relationship to discrete mathematics.

Geometry and Trigonometry Concepts

Level	Concepts
Mathematics	• Shapes and their properties • Mensuration • Similarity and congruence • Isometric transformations • Enlargement • Angles • Pythagoras' theorem • Trigonometry including the use of graphs • Vectors • Nets
Extended mathematics	• Similarity and congruence theorems • Non-isometric transformations • Trigonometric identities • 3D coordinate and vector spaces • Trigonometric graphs

Geometry and Trigonometry Skills

Level	Skills
Mathematics	• Naming and classifying • Applying area/volume formulae • Constructing • Rotating, reflecting, translating and enlarging • Solving problems by applying Pythagoras' theorem, trigonometric ratios and rules, properties of shapes and angles • Performing and discussing problem-solving strategies • Communicating and reasoning orally and in writing • Writing and solving problems involving the concepts at this level
Extended mathematics	• Justifying theorems for congruence, similarity, shape and angles • Justifying simple trigonometric identities and applying them to solve problems • Performing and discussing higher-level problem-solving strategies • Communicating and reasoning orally and in writing using mathematical language and conventions • Writing and solving problems involving the concepts at this level

Statistics and Probability

Statistical literacy is an awareness and understanding of the concepts and skills involved in collecting, collating and analysing data. Students should use these skills in their investigations and use a variety of technologies. They should be aware of both the power and limitations of statistics used to support and counter opinions and propaganda, how statistics may serve to emancipate and oppress, and how statistics may be used to both inform and misinform.

Teachers should help students develop the critical thinking skills that relate to understanding statistics and data analysis.

Students should be aware of the difference between what happens in theory (probability) and what is observed to happen (statistics).

Statistics and Probability Concepts

Level	Concepts
Mathematics	• Discrete and continuous data • Qualitative and quantitative data • Graphical analysis and graphical representation • Mathematical analysis • Sampling • Probability • Measures of central tendency (eg mean, mode, median)
Extended mathematics	• Bivariate Data • Linear regression • Normal distribution • Conditional probability • Measures of spread (eg standard deviation)

Statistics and Probability Skills

Level	Skills
Mathematics	• Sampling • Constructing plots and graphs appropriately • Calculating and locating statistics • Making inferences and drawing conclusions • Calculating probabilities of simple events • Performing and discussing problem-solving strategies • Communicating and reasoning orally and in writing • Writing and solving problems involving the concepts at this level
Extended mathematics	• Analysing time-series data and other bivariate data • Calculating probabilities of combined and conditional events • Making inferences about statistical analyses and probability calculations • Performing and discussing higher-level problem-solving strategies • Communicating and reasoning orally and in writing using mathematical language and conventions • Writing and solving problems involving the concepts at this level

Discrete Mathematics

An understanding of systems has become increasingly important for people to effectively participate in today's post-industrial/technological age.

Students should develop a sense of logic and be able to articulate this through Venn diagrams, structure diagrams and flow charts. This is a major contribution by mathematics to approaches to learning in the MYP.

Discrete mathematics is a relatively new branch of mathematics which has its roots in abstract algebra and has adopted the language and notations of graph theory. Students should be aware of the real-world applications of discrete mathematics which may include road or rail networks, computer networks, communication networks, optimal routes, time- and project-management techniques, and critical path analysis.

Discrete Mathematics Concepts

Level	Concepts
Mathematics	• Sets • Venn diagrams • Logic • Trees • Networks
Extended mathematics	• Topology • Directed networks

Discrete Mathematics Skills

Level	Skills
Mathematics	• Performing set operations • Constructing logical diagrams • Locating paths and tours • Solving problems involving optimal solutions • Performing and discussing problem-solving strategies • Communicating and reasoning orally and in writing • Writing and solving problems involving the concepts at this level
Extended mathematics	• Classifying and describing topological objects • Performing and discussing higher-level problem-solving strategies • Communicating and reasoning orally and in writing using mathematical language and conventions • Writing and solving problems involving the concepts at this level

Delivering MYP Mathematics

Introduction

One of the fundamental concepts of the Middle Years Programme is holistic learning which makes students aware—through coursework and activities—of the complementary nature of, and interactions between, the various disciplines.

When organizing their schemes of work schools need to consider coordination, coherence and consistency across all the disciplines in a subject group, and between the rest of the curriculum. It is essential that teachers work closely together, coordinating all aspects of teaching: content, approaches and assessment.

Regardless of how a school organizes its curriculum, it will need to take into account students' maturity and readiness for more challenging work. Year by year language, content, method and process need to be matched to the students' stage of development.

Schools' schemes of work need to integrate the following requirements and show how they will be fulfilled. These schemes of work must:

- be based on the areas of interaction (see Addressing the Areas of Interaction in this guide, and the MYP *Areas of Interaction* guide)
- allow students to meet the prescribed objectives
- identify lesson content using the subject group framework (if applicable)
- identify interdisciplinary work
- link suitable assessment with teaching and learning.

Well-planned schemes of work which address these requirements are the foundation of an effective delivery of the MYP.

Depending on local requirements and preferences, schools' schemes of work can be designed in many different ways. Schools could develop and implement:

- courses which integrate material from all the subject groups
- courses in discrete subjects
- courses which reflect a combination of discrete subjects and integrated subject material
- interdisciplinary projects linking several subject groups for part of the school year, while teaching discrete subjects the rest of the year.

Sample Schemes of Work

Sample 1

This sample scheme of work was provided by a school in the southern hemisphere. The school offers the MYP to all its students, many of whom follow the IB Diploma Programme when they finish the MYP.

The school's local requirements insist on a broad approach to the teaching and learning of mathematics. The school also recognizes the benefits of integrating the branches of mathematics, and offers one single mathematics course for every year of the programme. Only one mathematics class exists in each year group and the school requires teachers to differentiate learning to take into account the wide range of individual student needs. For this reason, only the main topics of learning are documented here. Teachers are then expected to provide students with individual learning plans based on these main topics.

The school has student grades validated by the IBO, and registers some students for certification in mathematics and others in extended mathematics. The choice of level for each student is made after consultation between teacher, parents and student during the final year of the programme.

Fundamental Concepts

As part of the school's overall policy on intercultural awareness, the scheme of work identifies many instances where teachers can infuse instruction with a variety of cultural, religious and national perspectives of mathematics. Teachers are encouraged to consider the role of language in conceptual development and to fully explore the various ways of communicating mathematics. Through the application of the areas of interaction, particularly approaches to learning and *homo faber*, students can grow to understand the similarities and contrasts between different approaches to human knowledge.

Areas of Interaction

- The scheme of work highlights areas where skill development can take place. The skills identified contribute to the school's overall scheme for **approaches to learning**.
- **Community service** projects involving mathematics were developed, for example projects conveying relevant information to the wider community.
- The school insists that students investigate local and global issues using a variety of skills developed across all subject groups. The scheme of work identifies suitable topics for investigation drawn from **environment** and **health and social education**.
- The mathematics department fostered strong academic links with other departments, and the scheme of work shows some areas where interdisciplinary studies take place. There is a very strong ***homo faber*** element in the whole school curriculum, and this is reflected in this scheme of work.

Yearly Schemes of Work

Key to abbreviations:

ATL: approaches to learning
CS: community service
EN: environment
HS: health and social education
HF: *homo faber*

Year 1

Topic Heading	Links to Areas of Interaction
Number	
• Whole number, multiples and factors and rational numbers	• Using concepts and skills (ATL) • Studying Muhammed al-Kwarizmi and the Hindu-Arabic number system (HF) • Drawing diagrams to illustrate concepts (ATL)
• Order of operation	• Recognizing concepts and applying skills (ATL) • Understanding order of priority when using the calculator (ATL)
• Number sets	• Using concepts and skills (ATL) • Drawing and understanding Venn diagrams (ATL, HF)
Algebra	
• Pattern recognition	• Recognizing concepts and applying skills (ATL) • Investigating Fibonacci sequence and Pascal's triangle (ATL, HF) • Using a graphic calculator (ATL)
• Simple equations involving geometry	• Applying problem-solving strategies (ATL) • Investigating architectural problems (EN)
• Forms of numbers, such as exponents	• Recognising the scientific necessity (ATL) • Learning to use the calculator (ATL)
Geometry and Trigonometry	
• Mensuration of perimeter and area	• Using measuring instruments and reading scales (ATL, HF) • Studying metric, imperial and base 60 measuring systems (ATL, HF) • Using appropriate computer software (ATL)
• Construction of triangles and quadrilaterals	• Investigating land use (EN, HS) • Using appropriate computer software (ATL)
• Transformations of reflections, rotations and translations	• Developing drawing skills (ATL) • Using fractals in visual art (HF) • Using appropriate computer software (ATL)

Topic Heading	Links to Areas of Interaction
Statistics and Probability • Collecting and collating data	• Using school weather station statistics (EN) • Using data from other aspects of the school environment, the city or the country (ATL, EN, HS)
• Presenting data using pie graphs, bar graphs, histograms and pictograms	• Studying environmental problems with the ecology class (EN) • Presenting data to the school community (CS) • Learning to use appropriate computer software (ATL)
Discrete Mathematics • Sets	• Using concepts and skills (ATL) • Drawing sets of the population of the city (EN) • Studying a forest population with the ecology class (EN)

Year 2

Topic Heading	Links to Areas of Interaction
Number	
• Ratios and proportions	• Using concepts and skills (ATL) • Studying … "Can the Peoples of the World Feed Themselves?" (HS) • Studying different measuring systems (HF)
• Percentages	• Monitoring pollution (EN) • Studying the Babylonians' system of taxation (HF)
• Estimation	• Using concepts and skills (ATL) • Using a graphic calculator and appropriate computer software (ATL)
• Number patterns	• Recognizing concepts and applying skills (ATL) • Using a graphic calculator and appropriate computer software (ATL)
• Scientific notation	• Using a system for writing large numbers in physics and astronomy (HF)
• Powers and roots of 2	• Exploring the regularity of numbers (HF)
Algebra	
• Language of algebra	• Researching the history of algebra (HF) • Recognizing concepts and applying skills (ATL)
• Flow charts	• Using flow charts in computer technology (HF)
• Expansion	• Recognizing concepts and applying skills (ATL) • Using algebraic tiles (ATL, HF)
• Equations	• Developing problem-solving strategies (ATL)

Topic Heading	Links to Areas of Interaction
Geometry and Trigonometry	
• Mensuration of perimeter and area	• Using concepts and skills (HF) • Researching the history of π (ATL, HF)
• Construction of circles and polygons	• Using drawing skills (ATL) • Using a pair of compasses (ATL) • Using appropriate computer software (ATL)
• Inscribed and circumscribed circles	• Researching the history of "trying to square the circle" (ATL, HF)
• Cartesian plane	• Researching the history of Descartes (ATL, HF)
• Transformations—reflections, rotations and translations in the Cartesian plane	• Drawing transformations (ATL) • Understanding and using systems for describing position, eg cursor on computer screen (ATL, HF)
• Enlargement	• Using concepts and skills (ATL) • Making scale drawings and understanding their use in architecture (ATL, HF) • Understanding the principles of the microscope and telescope (ATL, HF)
Statistics and Probability	
• Sample space, outcomes and events	• Recognizing concepts and applying skills (ATL)
• Theoretical and experimental probability	• Investigating lottery systems worldwide (HS) • Using data from disease control centres (ATL, HS)
Discrete Mathematics	
• Trees	• Using concepts and skills (ATL)

Year 3

Topic Heading	Links to Areas of Interaction
Number • Powers and roots of 3	• Exploring the regularity of numbers (HF)
• Irrational numbers	• Recognizing concepts and applying skills (ATL)
• Approximation	• Understanding concepts and uses (ATL) • Using appropriate computer software (ATL)
Algebra • Relations and linear functions including graph and value tables of linear functions	• Researching the history of algebra (HF)
• Expansion	• Recognizing concepts and applying skills (ATL) • Using the algebraic tile (ATL, HF)
• Equations	• Developing problem-solving strategies (ATL) • Understanding the epitaph on Diophantus' tomb (HF)
• Simple factorization with geometry	• Using concepts and skills (ATL) • Developing problem-solving strategies (ATL)
Geometry and Trigonometry • Pythagoras' theorem	• Using concepts and skills (ATL) • Using appropriate computer software (ATL) • Researching the history of Pythagoras (HF)
• Mensuration and classification of solids, including area and volume	• Using and developing classification systems (ATL) • Using drawing skills (ATL) • Studying the pyramids of Egypt, China and Mexico and the Platonic solids (HF)
Statistics and Probability • Organizing data using stem and leaf plots, and box and whisker plots	• Recognizing concepts and applying skills (ATL)
• Data analysis using mean, mode, median and range	• Using the concepts of central tendency and spread (ATL) • Using a graphic calculator and appropriate computer software (ATL)
Discrete Mathematics • Logic	• Using concepts and skills (ATL) • Using logic for computer programming (HF)

Year 4

Topic Heading	Links to Areas of Interaction
Number	
• Number sets	• Researching the history of numbers (HF) • Researching the history of π, e and the universal set ξ (ATL, HF)
• Theory of powers and roots	• Researching "Archimedes and the grain of sand" (ATL, HF)
Algebra	
• Expressions and factorization	• Using concepts and skills (ATL)
• Linear and quadratic functions	• Researching "Galileo and the Tower of Pisa" (ATL, HF)
• Simple linear equations with 2 variables	• Developing problem-solving strategies (ATL) • Studying "The Murder of Hypatia" (HF) • Using a graphic calculator and appropriate computer software (ATL)
Geometry and Trigonometry	
• Similarity and congruence	• Using concepts and skills (HF)
• Shape and perspective in 3D	• Developing drawing skills (ATL) • Developing visual art skills (ATL) • Using appropriate computer software (ATL)
• Trigonometry introduction	• Using concepts and skills (ATL)
Statistics and Probability	
• Data collection including sample frame, bias, target population and simple random sampling	• Recognizing concepts and applying skills (ATL) • Undertaking a project for the school and local communities (CS)
• Data analyses	• Understanding the concepts of central tendency and spread (ATL) • Understanding financial analysis (ATL) • Preparing an economic analysis of the country (ATL, HS)
Discrete Mathematics	
• Trees	• Using concepts and skills (ATL)
• Networks	• Using networks in computer technology (ATL, EN) • Undertaking a community service project using networks (CS)

Year 5

Topic Heading	Links to Areas of Interaction
Number	
• Finite and infinite (number sets)	• Researching "Newton and the Infinitessimal" (ATL, HF)
• Complex numbers	• Using complex numbers in computer technology (ATL, HF)
• Calculators and computers	• Researching "The First Calculators" (ATL, HF) • Researching Pascal and Leibniz (ATL, HF)
Algebra	
• Systems of inequalities	• Using concepts and skills (ATL) • Developing problem-solving strategies (ATL)
• Relations and functions (linear, conic, logarithmic, exponential)	• Using concepts and skills (ATL) • Developing problem-solving strategies (ATL) • Studying population growth with the biology class (ATL) • Studying "Newton and Leibniz: the controversy" (HF)
• Expressions	• Using concepts and skills (ATL)
• Recursive sequences and generating rules	• Recognizing concepts and applying skills (ATL) • Developing problem-solving strategies (ATL) • Using appropriate computer software (ATL)
Geometry and Trigonometry	
• Circles, triangles	• Using concepts and skills (ATL) • Studying "Copernicus, Galileo and their ideas about the universe" (HF)
• Vectors	• Using concepts and skills (ATL) • Using vectors to answer physics problems (ATL)
• Trigonometric identities	• Using concepts and skills (ATL) • Developing problem-solving strategies (ATL)
• Trigonometric graphs	• Using concepts and skills (ATL)
Statistics and Probability	
• Probability	• Using concepts and skills (ATL)
• Data analysis including variance and standard deviation	• Investigating and reporting on a school-based project (ATL, CS, EN, HS)
Discrete mathematics	
• Networks	• Developing problem-solving strategies (ATL) • Researching information on Euler (HF)
• Topology	• Studying "The Field of Mathematics" (HF)

Sample 2

This sample scheme of work was provided by a school in North America. All students in the school are MYP students and most of these follow the IB Diploma Programme when they finish the MYP. The language of instruction is French; most of the students are nationals of the country, and are bilingual in French and English.

The school follows a broad approach to the teaching and learning of mathematics and encourages integration of the branches. The mathematics department has drafted year-specific objectives based on the published objectives. Teachers are expected to use these year-specific objectives to organize teaching and learning for each mathematics class. To help teachers and students best understand their progress, the department has devised suitable assessment tasks for each class based on the published assessment criteria. In addition, the department has drafted year-specific descriptors for the levels of achievement in each assessment criterion.

In years 1 to 3, five teaching hours per week are assigned for mathematics. In years 4 and 5, the department considers it essential to allow students exposure to the skills and concepts of the extended mathematics level, although they realize that not all students who opt for certification will be registered at that level. All year 4 and 5 students have five hours of mathematics instruction per week; those who opt to study extended mathematics have additional lessons in the school's weekly schedule.

Students can be registered for certification in either mathematics or extended mathematics, and the final decision is made during the fifth year of the programme.

Yearly Schemes of Work

Year 1: Mathematics

Branches	Objectives
Number	Students should be able to: • investigate problems involving several operations on natural numbers and rational numbers • apply algorithms to integers in various situations • compare rational numbers in different forms • learn to estimate with whole numbers.
Algebra	Students should be able to: • express the rule for algorithms in symbolic language • investigate problems with one missing term including examples from geometry • calculate the value of the variable.
Geometry and Trigonometry	Students should be able to: • investigate problems involving triangles • investigate problems involving convex quadrilaterals • investigate problems involving the perimeter or the area of certain polygons • investigate problems involving straight lines or angles • create figures by means of isometric transformations.
Statistics and Probability	Students should be able to: • interpret tables and graphs • construct tables and graphs • calculate averages.
Discrete Mathematics	Students should be able to: • perform set operations with whole numbers • find the cardinality of sets.

Year 2: Mathematics

Branches	Objectives
Number	Students should be able to: • investigate problems involving ratios and rates • investigate problems involving proportions and percentages • investigate problems with squares and square roots • estimate with rational numbers • approximate irrational numbers.
Algebra	Students should be able to: • demonstrate their understanding of the concept of an expression • carry out basic operation on expressions (+, –, ×, ÷) • translate one representation of a situation into another (rules, graphs, tables of values) • investigate first-degree equations • investigate problems using a table of values or a graph.
Geometry and Trigonometry	Students should be able to: • investigate problems involving polygons • investigate problems involving circles • investigate problems involving enlarging or reducing a figure • create figures by means of isometric transformations in the Cartesian plane.
Statistics and Probability	Students should be able to: • calculate the probability of an event in a simple situation • investigate probabilities • use Venn diagrams to investigate problems.
Discrete Mathematics	Students should be able to: • perform set operations with rational numbers • find the cardinality of sets • locate paths and tours • investigate probability problems using trees.

Year 3: Mathematics

Branches	Objectives
Number	Students should be able to: • work with rational numbers • approximate some rational numbers • perform and discuss problem-solving strategies • investigate problems involving cubes and cube roots.
Algebra	Students should be able to: • determine the dependent variable and independent variable in a variety of situations • represent rules that apply to given situations in various ways • investigate problems where a linear relationship exists between variables • convert an algebraic situation into an equivalent expression using basic operations • investigate first-degree inequations.
Geometry and Trigonometry	Students should be able to: • investigate problems by applying Pythagoras' theorem • create figures using composites of transformations • describe, identify and prove some composites of transformations • create solids by rotating or translating figures • investigate problems involving solids • investigate problems related to the area or volume of solids.
Statistics and Probability	Students should be able to: • investigate problems involving situations represented by a one-variable statistical distribution • derive qualitative information about a distribution using mean, median, mode and range
Discrete Mathematics	Students should be able to work with a logic table.

Year 4 : Mathematics and Extended Mathematics

Branches	Objectives for Mathematics	Objectives for Extended Mathematics
Number	Students should be able to: • investigate problems involving an exponential • recognize irrational numbers and investigate problems with an approximation.	Students should be able to: • recognize irrational numbers • investigate problems with approximations and real values.
Algebra	Students should be able to: • investigate problems dealing with systems of linear relations • analyse variations using different modes of representation • analyse basic polynomial functions of the second degree • transform an algebraic expression into an equivalent expression with polynomials.	Students should be able to: • analyse variations using different modes of representation • transform an algebraic expression into an equivalent expression with polynomials • analyse polynomial functions of the second degree • investigate problems involving factorization • investigate problems using a system of equations in two variables • investigate problems with inequations in the Cartesian plane • investigate problems involving three dimensions using coordinate systems.
Geometry and Trigonometry	Students should be able to: • investigate problems using the concept of similarity • investigate problems using trigonometric ratios • investigate problems in analytic geometry.	Students should be able to: • investigate problems using the concept of similarity • investigate problems using trigonometric ratios • investigate problems in analytic geometry • investigate problems using theorems of isometry, similarity and equivalence • create figures under non-isometric transformations • justify solutions to problems with a statement.
Statistics and Probability	Students should be able to: • investigate problems using measures of position • analyse statistical data • collect data.	Students should be able to: • investigate problems using measures of position • analyse statistical data • use appropriate data-collection techniques.
Discrete Mathematics	Students should be able to: • investigate problems involving optimal solutions • perform and discuss problem-solving strategies.	Students should be able to: • investigate problems involving optimal solutions • perform and discuss a variety of problem-solving strategies.

Year 5 : Mathematics and Extended Mathematics

Branches	Objectives for Mathematics	Objectives for Extended Mathematics
Number	Students should be able to investigate problems using graph theory.	Students should be able to: • investigate problems using absolute values • investigate problems using graph theory • use logarithms.
Algebra	Students should be able to: • investigate problems using systems of inequations with optimization techniques • investigate problems by using simple functions • transform mathematical expressions involving variables into equivalent expressions • investigate problems using geometric loci associated with first and basic second degree relations in the Cartesian plane.	Students should be able to: • investigate problems using systems of inequations with optimization techniques • investigate problems using functions • transform mathematical expressions involving variables into equivalent expressions • investigate problems using geometric loci associated with first and second degree relations in the Cartesian plane.
Geometry and Trigonometry	Students should be able to: • investigate geometry problems involving circles and triangles • investigate geometry problems in the Cartesian plane • analyse some geometric situations • justify the solution of a problem with a statement.	Students should be able to: • investigate geometry problems involving circles and triangles. • investigate geometry problems involving vectors • investigate geometry problems in the Cartesian plane • analyse a variety of geometric situations • justify the solution of a problem with a statement.
Statistics and Probability	Students should be able to: • investigate problems involving a one-variable statistical distribution • analyse statistical data • calculate probabilities of combined events.	Students should be able to: • investigate problems involving a one- or two-variable statistical distribution • analyse statistical data • calculate probabilities of combined and conditional events.
Discrete Mathematics	Students should be able to investigate problems involving networks.	Students should be able to: • investigate problems involving networks and directed networks • classify and describe topological objects including the Möbius strip.

Assessment

Introduction to Assessment

There is no external assessment by the IBO within the Middle Years Programme (MYP) in that there are no formal externally-set or externally-marked examinations. All assessment within the MYP is carried out by teachers in participating schools and relies on their professional expertise in making qualitative judgments, as they do every day in the classroom. In line with the general IBO assessment philosophy, a norm-referenced approach to assessment is not appropriate to the MYP. Instead MYP schools must follow a criterion-referenced approach. Students' work should therefore be assessed against defined assessment criteria and not against the work of other students.

This section provides:

- advice on assessment in years 1 to 5
- guidelines for final assessment
- the assessment criteria and final level descriptors
- the moderation procedures which teachers must follow if their school decides to register candidates for IBO-validated grades
- final grade descriptors.

All MYP schools are expected to develop assessment procedures and methods of reporting to parents which reflect the philosophy and objectives of the programme. All schools are therefore expected to use the assessment criteria published in this guide, although local or national requirements may involve other assessment models and criteria as well.

It is highly recommended that the procedures for assessment and the MYP assessment criteria are shared with both students and parents as an aid to the learning process.

> For schools which request **IBO-validated grades**, the criteria and corresponding levels of achievement listed in this guide **must** be used as a basis for the grades submitted to IBCA. For these schools, standardization of assessment is ensured through a process of external moderation of teachers' internal assessments.

The *MYP Coordinator's Handbook* provides further details concerning the registration of candidates for certification and the process of external moderation.

Assessment in Years 1 to 5

Formative and Summative Assessment

Assessment in the MYP should be an integral part of teaching and learning. The use of assessment in a formative sense, to judge regularly the effectiveness of both teaching and learning processes, is essential to allow teachers and students to identify strengths and weaknesses. The purpose and means of assessment should be clearly explained to the students.

- **Formative assessment** is an integral part of the learning experience and should not be an artificial "add-on". The objectives addressed by specific assessment tasks should be shared with students, with feedback taking place as soon as possible.
- **Summative assessment** is the judgment made by the teacher of the standard of achievement reached by each student at the end of each stage of the programme. Assessment tasks should reflect the objectives and assessment criteria of the programme. They must be carefully chosen to measure the level of achievement expected for the relevant age group.

The forms of assessment and reporting to parents and students will vary from one school to another. The flexibility of the MYP offers schools the opportunity to design their schemes of work according to their needs, and/or the constraints of their own national curriculum, while working towards the attainment of common MYP objectives.

Formative and **summative** assessment should:

- allow both the student and teacher to assess what the student can do, and how he/she can use knowledge and skills
- allow the application of knowledge and skills rather than the mere recall of facts
- involve student participation and reflection; for example, students should know the assessment criteria for a given task and, on occasion, help devise an assessment grid (rubric) to measure various aspects of their performance
- provide students with an opportunity to analyse their own learning and to recognize what areas need improvement
- be based on agreed standards of performance for a particular year group, with expectations set by teams of classroom teachers and clearly communicated to students and parents
- be informative for students, parents and teachers, and provide direction for future instruction
- include references to consistent objectives and standards across the subjects such as approaches to learning (ATL) skills and attitudes, and collaborative work
- reflect achievement against the criteria for the subject, and provide equal opportunities for all students regardless of gender, culture and special needs.

Depending on circumstances, students will reach the objectives at different times and in different ways. The MYP provides schools with a series of final objectives for each subject, and schools are free to organize both teaching and assessment according to their needs.

Use of Assessment Criteria

The assessment criteria published in this guide correspond to the objectives of this subject group. The levels of achievement described have been written with year 5 final assessment in mind. In years 1–4 schools will need to adapt the relative importance, focus and expected levels of achievement for each criterion according to the progression of learning organized by them. Schools may add other criteria and report on these **internally** to parents and students.

Process Assessment

The MYP places approaches to learning at the core of the curriculum. As students develop their own strategies for learning and problem solving, some assessment tasks may focus less on the actual result or product than on the thought processes leading to the desired outcome.

Writing journals or logbooks and exchanging information with the teacher or fellow students are typical activities for the assessment of process. They all involve responses to questions such as "How did you…?" or "Explain the steps you used…" and so provide information on the strategies used by the student to achieve certain results. Process assessment requires the student to reflect upon and find out how a product or performance has been achieved, what worked and what did not work.

Process assessment is highly indicative of the student's understanding and can be used as formative assessment. It helps the student to develop an approach to learning and can be used in connection with many types of assessment tasks.

Assessment Tasks

In general, MYP teachers are free to devise the exact nature of the assessment tasks that they use. Assessment should be based on a variety of types of activity since no one task will cover all the objectives of an MYP subject. Projects, exhibitions, oral presentations, performances and demonstrations as well as written papers or essays all provide evidence for assessment of student learning. The tasks set, however, should stem from learning activities and may indeed be learning experiences themselves. If the tasks are complex they will allow the assessment of different kinds of skills and knowledge against the relevant criteria.

The assessment tasks should allow students to experience varied levels of support, since peer-conferencing, teacher-conferencing, editing and correcting are all essential learning tools.

When assessing each piece of work, whether formatively or summatively, teachers should bear in mind the level of difficulty of the task. Teachers should also consider the amount of support provided for the student, for example, whether the work is:

- unsupported or spontaneous, ie a first draft
- written under test conditions
- polished and edited, ie a final draft
- a product for which the student had access to documentation or outside help.

This would affect the standards that teachers expect of their students' work and the nature of the feedback that they give. If students collaborate on a specific task, teachers must ensure that sufficient individual work is carried out to enable individual assessment.

Final Assessment

When organizing the **final** assessment, teachers must use the MYP assessment criteria which are based on the subject group objectives. Depending on local circumstances, teachers may also want to report internally on students' work according to other criteria.

This does not imply that the final assessment should be based simply on one final test or examination. Teachers should take into account a range of assessment activities undertaken towards the end of the course to arrive at a final grade.

Internal Standards

When planning the final assessment of their students, schools and teachers should keep in mind the following points.

- The process of averaging year 5 assessments against any of the criteria must not be used to make a final decision on each student's performance, since students can develop academically right up to the end of the programme. The teacher must make a professional judgment as to which level best corresponds to the student's general level of performance for each of the criteria towards the end of the programme.
- In cases where several teachers are involved in the assessment of the same subject, they should carry out their own process of **internal standardization** to ensure that similar standards have been applied to all students.

Using the Criteria in Final Assessment

Procedure

The descriptors for each criterion are hierarchical. When assessing a student's work, teachers should read the descriptors (starting with level 0) until they reach a descriptor which describes a level of achievement that the work being assessed has **not** attained. The work is therefore best described by the preceding descriptor which corresponds to a mark band.

Care should be taken to apply criteria only to pieces of work for which they are appropriate. Where it is not clearly evident which level descriptor should apply, teachers must use their judgment to select the descriptor which best matches the student's work.

If the work is a particularly good example of achievement in a mark band, the teacher should give it the upper level in the band. If the work is a poor example of achievement in that band, the teacher should give it the lower level in the band.

General Principles

- Only whole numbers should be recorded; partial levels, fractions and decimals are not acceptable.
- The levels attributed to the descriptors must not be considered as marks or percentages, nor should it be assumed that there are arithmetical relationships between descriptors. For example, a level 4 performance is not necessarily twice as good as a level 2 performance.
- Teachers should not think in terms of a pass/fail boundary for each criterion, or make comparisons with the MYP 1–7 grade scale, but should concentrate on identifying the appropriate descriptor for each assessment criterion.
- The highest descriptors do not imply faultless performance, but should be achievable by students aged 16. Teachers should therefore not hesitate to use the highest and lowest levels if they are appropriate descriptors for the work being assessed.
- A student who attains a high level of achievement for one criterion will not necessarily reach high levels of achievement for the other criteria. Conversely, a student who attains a low level of achievement for one criterion will not necessarily attain low levels of achievement for the other criteria.
- Teachers should not assume that the results of a group of students being assessed will follow any particular distribution pattern.

For schools which request IBO-validated grades, the assessment results submitted to IBCA must be based only on the criteria and levels of achievement listed in this guide. The teacher's final assessment of each student as recorded on the MYP marksheet should be the total of the levels of achievement which best reflect the student's abilities at the **completion** of the programme.

MYP Mathematics Assessment Criteria

General

The assessment criteria listed in the table below apply to both levels of MYP mathematics. Final assessment at the end of the MYP must be based on these assessment criteria.

Criterion A	Knowledge and Understanding	Maximum 10
Criterion B	Application and Reasoning	Maximum 10
Criterion C	Communication	Maximum 6
Criterion D	Reflection and Evaluation	Maximum 8

- For each assessment criterion, a number of band descriptors are defined. These describe a range of achievement levels with the lowest level represented as 0.
- The criteria are not equally weighted.
- The descriptors concentrate on positive achievement, although failure to achieve may be included in the description for the lower levels.

The assessment criteria and band descriptors appear on the following pages.

The process by which a student's total level of achievement (in terms of the assessment criteria) is finally converted to a single grade can be found in the *MYP Coordinator's Handbook*.

For schools which request **IBO-validated grades**, these criteria and final level descriptors **must** be used for assessing students' work sent for moderation, and for final assessment of all students registered for certification in **mathematics** and in **extended mathematics**.

Criterion A: Knowledge and Understanding

Maximum 10

Students are expected to have a knowledge and understanding of the concepts and skills of MYP mathematics as shown in the prescribed framework.

This criterion includes:

- *using knowledge and understanding to make deductions*
- *using numeric, algebraic, geometric, graphical and other forms of representation*
- *moving between different forms of representation*
- *using appropriate technology.*

Level of Achievement	Descriptor
0	The student does not reach a standard described by any of the descriptors given below.
1–2	The student demonstrates **minimal mathematical knowledge** and **attempts** to use different forms to represent mathematical ideas.
3–4	The student demonstrates **partial** knowledge and understanding of the subject material. The student uses a **limited range** of forms to represent mathematical ideas.
5–6	The student demonstrates **sufficient** knowledge and understanding of the subject material to **make deductions**. The student uses a **variety** of forms to represent mathematical ideas.
7–8	The student demonstrates a broad knowledge and a **good** understanding of the subject material, and makes deductions **with some insight**. The student moves between different forms of representation in **most situations**.
9–10	The student demonstrates a **thorough** knowledge and a **comprehensive** understanding of the subject material and is able to make deductions with insight **even in unfamiliar situations**. The student moves **confidently** between different forms of representation.

Notes

1. Assessment tasks should allow students to demonstrate knowledge and understanding of the concepts and skills within the appropriate level of MYP mathematics.
2. Assessment tasks for this criterion are likely to be class tests and/or examinations. Teachers are encouraged to use other tasks also, such as open-ended investigations.
3. Assessment tasks should provide students with problems set in a variety of contexts.

Criterion B: Application and Reasoning

Maximum 10

Students are expected to apply concepts and skills and, through reasoning, develop problem-solving strategies.

This criterion includes:

- *selecting and using appropriate mathematical knowledge and skills*
- *recognizing patterns and structures and describing them as relationships or general rules*
- *drawing conclusions consistent with findings*
- *justifying mathematical relationships*
- *developing flexible strategies, including the use of appropriate technology.*

Level of Achievement	Descriptor
0	The student does not reach a standard described by any of the descriptors given below.
1–2	The student uses **limited** mathematical knowledge and recognizes **simple** patterns or structures when investigating problems. The student applies **basic problem-solving techniques** to routine tasks.
3–4	When investigating problems the student recognizes patterns and **suggests relationships** or **general rules**. The student applies skills and problem-solving techniques **with some success**.
5–6	When investigating problems the student recognizes patterns and structures, describes them as relationships or general rules and **draws conclusions**. The student applies appropriate skills and problem-solving techniques and uses **appropriate technology** to a limited extent.
7–8	When investigating problems of **some complexity** the student recognizes patterns and structures, describes them as relationships or general rules and **draws conclusions consistent with findings**. The student successfully **selects** and applies skills and problem-solving techniques. The student makes **reasoned choices** for the use of technology, where appropriate.
9–10	When investigating **challenging** problems, the student recognizes patterns and structures, describes them as relationships or general rules, draws conclusions and **provides justifications or proofs**. The student selects and applies **advanced** problem-solving techniques including the use of technology where appropriate.

Notes

1. Assessment tasks should allow students to demonstrate their ability to apply and reason using concepts and skills of the appropriate level of MYP mathematics.
2. Assessment tasks for this criterion are likely to be reasoned pieces of work, including open-ended investigations set in a variety of contexts.
3. Little credit should be given for knowledge and understanding which is assessed using criterion A.

Criterion C: Communication

Maximum 6

Students are expected to communicate facts, ideas, methods, results and conclusions using appropriate symbols and the language of mathematics.

This criterion includes:

- *encoding and decoding*
- *describing in words (verbalizing) a line of reasoning*
- *explaining solutions*
- *presenting mathematical information clearly and logically*
- *using appropriate technology for effective communication.*

Level of Achievement	Descriptor
0	The student does not reach a standard described by any of the descriptors given below.
1–2	The student recognizes and uses **basic** mathematical symbols and language. An **attempt** is made to verbalize when investigating problems set in familiar contexts. The student presents **some** mathematical information clearly.
3–4	The student recognizes and uses **a range of** mathematical symbols and language. The lines of reasoning are **verbalized** and the solutions to problems are **explained**. Mathematical information is presented **clearly and logically**.
5–6	The student recognizes and uses a **wide range** of mathematical symbols and language. The student verbalizes **effectively** and explains solutions to problems **clearly**. The student chooses and uses the **most appropriate technology** to present mathematical information clearly and logically.

Notes

1. Assessment tasks should allow students to communicate effectively when using concepts and skills of the appropriate level of MYP mathematics.
2. Assessment tasks for criteria A, B and D can also be used for this criterion.

Criterion D: Reflection and Evaluation

Maximum 8

Students are expected to reflect upon methods and processes and to evaluate the significance and reliability of their findings and the findings of others. It is expected that students will consider alternative approaches to solving problems where relevant.

This criterion includes:

- *reflecting upon and evaluating methods and processes used during investigations which could be open-ended*
- *considering the use of technology where appropriate.*

Level of Achievement	Descriptor
0	The student does not reach a standard described by any of the descriptors given below.
1–2	The student **attempts** to justify the method used and to **evaluate** the reliability of findings.
3–4	The student **justifies** the method and the majority of processes used. The student **evaluates** the reliability of findings with some success.
5–6	The student presents a **reasoned** justification for the method and processes, and provides an evaluation of the **significance** and reliability of findings. The student suggests **other approaches** to solving the problem, where relevant.
7–8	The student presents a **concise**, reasoned justification for the method and processes and, where relevant, **considers fully** the range of approaches which could have been used, including the use of technology. The student makes a **thorough evaluation** of the significance and reliability of findings.

Notes

1. Assessment tasks are likely to be reports on investigations undertaken using concepts and skills of the appropriate level of MYP mathematics.
2. Assessment tasks should give students clear instructions to reflect and evaluate.
3. Assessment tasks should focus on the individual's ability to reflect and evaluate.

Moderation

The following details apply only to schools which request **IBO-validated grades**.

Teachers should note that there are three distinct phases to the moderation process:

- **Phase 1**—submission of **moderation samples**
- **Phase 2**—submission of **MYP marksheets**
- **Phase 3**—award of **MYP grades**.

Purpose of Moderation

The external moderation procedure in all MYP subjects and the personal project exists to ensure that students from different schools and different countries receive comparable grades for comparable work, and that the same standards apply from year to year.

All MYP assessment is carried out by the students' own classroom teachers (or by the supervisors in the case of the personal project). The IBO moderation procedures ensure that the final judgments made by these teachers all conform to an agreed scale of measurement on common criteria.

To ensure this comparability and conformity, moderation samples submitted to IBCA **must** be assessed using the assessment criteria and levels of achievement listed in this guide.

Phase 1: Submission of Moderation Samples

Schools must submit a **moderation sample** to IBCA for each level of mathematics registered for moderation. Each moderation sample must include eight **folders** of **students' work** with each folder representing the work of a single student. In each folder teachers must include a completed **coversheet F3**, and for each piece of students' work, a description of the **assessment task** and any **background information** must be supplied.

Prescribed Minimum

In order to meet the required number of judgments against each criterion, the following three pieces of work must be submitted in each folder.

1. A **broad-based classroom test/examination** composed of a range of questions which allowed students to reach all levels of achievement.
2. A **reasoned piece of work** in which the student had opportunities to apply mathematics in an everyday situation, and to reflect upon and evaluate findings.
3. A **written report** in which the student reflected upon methods and processes, and evaluated findings of an **investigation**, which could be open-ended.

Additional Students' Work

Each folder may only contain additional pieces of students' work (including assessment tasks and background information) if these are necessary to fulfill the required number of judgments against each assessment criterion.

Important Notes

- In each moderation sample, teachers' assessments of students' work must be entirely based on the criteria published in this guide.
- Students' work submitted should reflect the types of assessment tasks used by the teacher for final assessment; ideally there should be a range of assessment tasks.
- In each folder, all the student's work submitted must be supported by evidence illustrating the teachers' application of the assessment criteria. Such evidence includes marking schemes (with a copy of the relevant worksheet, test paper, etc) and descriptions of the ways the assessment tasks were presented to the student.
- In each folder, the background information should document details which may be useful to the moderators (such as the time allocation for an assessment task, degree of teacher support, etc).
- In cases where group work is involved, care must be taken to assess the work of each individual student.
- Teachers should ensure that the correct number of judgments are recorded for each criterion on the coversheet F3.

> The submission date for moderation samples is likely to come well before the end of a school's academic year. Schools must continue to make further assessments of students' work after moderation samples have been submitted.

The *MYP Coordinator's Handbook* provides further guidelines on submitting moderation samples in each subject.

Phase 2: Submission of MYP Marksheets

Phase 1 of the moderation process takes place before the end of most schools' academic year. After submitting moderation samples, teachers should continue to assess students' work until **final assessment**.

After final assessment, teachers should use the following procedure to arrive at a criterion levels total and estimated grade for each student registered for certification.

1. In cases where several teachers are involved in the assessment of the same subject, they **must** carry out their own process of **internal standardization** to ensure that similar standards have been applied to all students. In certain schools, students may be grouped according to ability within the same subject. In such cases, the teachers' final assessment of students' performance across all groups must be based on a **consistent application of the assessment criteria to all students**. A different standard should not be applied to different groups.
2. When the judgments on the variety of assessment tasks have been made, teachers must establish each student's final profile of achievement. This is done by determining the single most appropriate level for each criterion. These levels must then be added together to give a **criterion levels total** for each student.

3. Teachers must use the **grade boundaries** for their subject published in the *MYP Coordinator's Handbook* to determine an **estimated grade** for each student.
4. Each registered student's criterion levels total and estimated grade must be entered on the MYP **marksheet**, which should be sent to IBCA.

Phase 3: Award of MYP Grades

Following moderation in each subject, IBCA may, where appropriate, apply a moderation factor to the criterion levels totals submitted by a school. Final MYP grades will then be determined by applying grade boundaries to these moderated totals.

Schools will receive notification of the final grades for their students and IBCA also provides a general and a school-specific moderation report for each subject in which candidates were registered.

The *MYP Coordinator's Handbook* provides further guidelines on submitting MYP marksheets in each subject.

General Grade Descriptors

The generic grade descriptors which illustrate the MYP 1–7 grade scale are stated below. They should be considered as broad descriptions: simpler, more generalized statements about the skills and knowledge mastered by the student. They are not specific to any particular subject group assessment criteria.

The assessment philosophy established for the MYP requires a criterion-referenced approach rather than one that is norm-referenced. Therefore, the inclusion of normative type statements such as "above average" has been avoided. The approach relies on teachers' professional expertise in making qualitative judgments in the same way that they do every day in the classroom.

IBCA uses these descriptors to determine grade boundaries for subject groups and the personal project. Grade boundaries are published in the *MYP Coordinator's Handbook*.

Grade	Descriptors
Grade 1 (Very poor)	**Minimal** achievement in terms of the objectives.
Grade 2 (Poor)	**Very limited** achievement against all the objectives. The student has difficulty in understanding the required knowledge and skills, and is **unable** to apply them fully in normal situations, **even with support**.
Grade 3 (Mediocre)	**Limited** achievement against most of the objectives, or clear difficulties in some areas. The student demonstrates a **limited understanding** of the required knowledge and skills and is **only able to apply** them fully in normal situations **with support**.
Grade 4 (Satisfactory)	**A good general understanding** of the required knowledge and skills, and the ability to apply them effectively in **normal** situations. There is **occasional** evidence of the skills of analysis, synthesis and evaluation.
Grade 5 (Good)	**A consistent and thorough understanding** of the required knowledge and skills, and the ability to apply them in a variety of situations. The student **generally** shows evidence of analysis, synthesis and evaluation where appropriate and **occasionally** demonstrates originality and insight.
Grade 6 (Very good)	A consistent and thorough understanding of the required knowledge and skills, and the ability to apply them in a **wide variety** of situations. There is **consistent** evidence of analysis, synthesis and evaluation where appropriate. The student **generally** demonstrates originality and insight.
Grade 7 (Excellent)	A consistent and thorough understanding of the required knowledge and skills, and the ability to apply them **almost faultlessly** in a wide variety of situations. There is consistent evidence of analysis, synthesis and evaluation where appropriate. The student **consistently** demonstrates originality and insight and **always** produces **work of high quality**.

Glossary of MYP Terms

aims

The aims of a programme state, in a general way, what the teacher may expect to teach or do, what the student may expect to experience or learn and how the student may be changed by the learning experience.

approaches to learning (ATL)

One of the areas of interaction; it is concerned with the development of effective study skills and the ability to reflect on one's own learning.

area leaders

Leaders designated by individual schools for each of the areas of interaction; they are entrusted with liaison between the teachers involved, parents, students and, if necessary, the community.

areas of interaction

The five common themes embedded within and across the academic subjects of the MYP curriculum. They are:

- approaches to learning (ATL)
- community service
- health and social education
- environment
- *homo faber*.

assessment criteria

Criteria against which a candidate's performance is measured as evidenced by work produced. MYP subject guides provide assessment criteria for each subject group and the personal project to be used for the final assessment of students.

assessment grid

A matrix linking the various methods of assessment to the skills and content to be assessed.

assessment objective

One of a set of statements for a subject describing the required skills, knowledge and understanding in a subject.

candidate

A student who has been registered with the IBO by the school for the issue of a record of achievement (listing results in subject areas and the personal project, as well as community service) and the certificate (for students who have fulfilled all conditions as stated in the *MYP Coordinator's Handbook*).

community service

One of the areas of interaction; it is concerned with the acquisition of experience through social activities within and outside school.

criterion-referenced assessment

An assessment process based on awarding grades against previously agreed criteria. MYP assessment is criterion referenced.

descriptors

These describe the levels of achievement which are assessed in particular skill areas.

environment — One of the areas of interaction; it is concerned with the interdependence of human beings and nature, and with sustainable development.

external moderation — see **moderation**

final assessment — The summative assessment of students at the end of the final year of the MYP.

fundamental concepts — The basic educational principles of the MYP. They include a holistic view of knowledge, intercultural awareness and the importance of communication.

grade boundaries — The lowest and highest marks for a particular grade. These are determined for each subject and published in the *MYP Coordinator's Handbook*.

grades — Schools must assess candidates from "very poor" to "excellent" on a 1–7 scale for final assessment. Schools can also use this scale for assessment other than final assessment.

Grade 1	Very poor
Grade 2	Poor
Grade 3	Mediocre
Grade 4	Satisfactory
Grade 5	Good
Grade 6	Very good
Grade 7	Excellent

health and social education — One of the areas of interaction; it is concerned with mental and physical health, and the interactions between the individual and community.

holistic education — One of the fundamental concepts of the MYP; it is an interdisciplinary perspective which accentuates the interrelatedness of various disciplines and issues.

homo faber — One of the areas of interaction; it is concerned with the products of the creative and inventive genius of people and their impact on society.

integrated subjects — Within each of the subject groups, schools may teach individual subjects (eg history and geography within humanities) or an integrated course with elements of each subject every year.

internal assessment — The assessment of a student's work which is carried out by the student's teacher.

issue of results — The issue of MYP records of achievement and certificates by the IBO, following the moderation of the schools' internal assessment. The documents are sent directly to schools within a month of their submission of results of internal assessment (only for schools which request IBO-validated grades).

judgment — The consideration of a candidate's work against assessment criteria.

mark — A student's mark in a subject is the sum of the levels achieved against all the criteria in that subject. The levels total is then converted to a grade from 1–7 by applying the grade boundaries.

Middle Years Programme (MYP) — The IBO's programme designed for students between the ages of 11 and 16 years. It is organized according to the fundamental concepts of holistic education, communication and intercultural awareness.

moderation — The procedure by which sample marked work from teachers is reviewed externally to ensure assessment has been carried out according to criteria and standards as laid down. Adjustment of marks by moderators may be necessary (only for schools which request IBO-validated grades).

moderation factor — Where samples of students' work submitted by a school show that the standards applied by the teachers vary significantly from MYP standards, a moderation factor is applied to the results of internal assessment sent in by the school.

MYP certificate — The official IB document stating that the candidate has fulfilled the requirements for the award of the MYP certificate.

MYP coordinator — The contact person for IBO offices in an MYP school. This coordinator ensures the effective implementation of the MYP, particularly with respect to the areas of interaction.

MYP marksheets — These sheets are completed by schools and provide a mark for internally assessed subjects and the personal project, and a predicted final grade on a 1–7 scale.

norm-referencing — Norm-referenced assessment is constructed to distribute students above and below a pre-set pass or fail line and candidates are measured against each other. MYP assessment is not norm referenced.

objective — One of a set of statements for a subject or the personal project, describing the skills, knowledge and understanding which will be assessed in the course/project. The assessment criteria correspond to the objectives.

personal project	The manifestation of a student's experience of the areas of interaction; completed during the last year of the five-year cycle.
personal project supervisor	The member of staff within a school who is responsible for working directly with the student on the completion of the personal project.
portfolio of achievement	A folder provided by the IBO for each of a school's graduating students, whether or not they are registered as candidates for the MYP certificate and/or record of achievement. The school inserts and retains IB documents as well as school-produced records and statements in this portfolio.
portfolio of work	Selected samples of a student's work in a given discipline, showing achievement against the corresponding assessment criteria.
predicted grade	The prediction of a candidate's performance by the teacher.
programme evaluation	A mandatory process for all authorized MYP schools, whereby the IBO ensures quality of programmes, as well as assisting schools in their own self-evaluation procedures.
record of achievement	Issued by the IBO to all candidates for the MYP certificate, the record of achievement lists moderated results in the subject groups, the personal project and, where relevant, the satisfactory completion of community service.
registration	The procedures whereby candidates are entered for the MYP certificate and/or record of achievement.
sample schemes of work	These examples provide some suggested means of enabling students to achieve the prescribed MYP objectives. Schools may use these examples or write their own schemes of work.
sample work	Work submitted by schools, on the instructions of IBCA, for review by IBO-appointed moderators.
subject groups	The MYP curriculum includes eight subject groups: language A, language B, humanities, sciences, mathematics, the arts, physical education and technology.
subject group guide	A guide, published by the IBO for each of the subject groups, stating the mandated objectives and providing sample schemes of work.
teaching hour	One teaching hour equals 60 minutes.
weighting	A measure of the importance of each assessment criterion.

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IBO Online

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- Online curriculum centre for IB teachers (password protected): http://www.online.ibo.org

Regional Offices

Regional offices of the IBO around the world provide services to member schools, arrange teacher training events and conferences, and assist schools in communications with the International Baccalaureate headquarters in Geneva and the Curriculum and Assessment Centre in Cardiff.

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