Mathematics

Transition from Secondary School to College

Presentation by:

Sean Allen
Cindy Eccles

Limestone District School Board

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Differences between the Old Curriculum and the New Curriculum

The new curriculum is expectation based rather than objective based. The new curriculum empowers the learner as they achieve expectations rather than the emphasis being on the teacher meeting objectives. Specifically, the new curriculum focuses on student exploration and discovery of a topic, therefore "learning through doing". Since it has more emphasis on discovery, problem solving is paramount, rather than memorization. In the new curriculum, the course levels are matched to the student's way of learning more than intellectual ability. Specifically, if a student can handle theoretical and abstract concepts, they are more suited for the academic level. The academic level focuses on exploring higher ordered thinking. Practical and concrete learners have their place in the applied level. Each course is then taught in the particular domain as either theoretical or practical. The shift from the old curriculum to the new curriculum has been one that has taken ability-based courses and moved towards a "destination based" curriculum. All courses channel students according to where they would like to end up at the conclusion of high school.

One downfall of the new curriculum is that the students have less time to complete a similar amount of work as had been expected in the old curriculum. Changing a 5-year program into a 4-year program has its growing pains. Specifically, many topics that would have been learned close to the completion of high school are now pushed ahead to the early years.

One benefit of the new curriculum is that a clearly stated set of course expectations brings more consistency, by stating the criteria for assessment (achievement charts) , between how the course is taught from school to school. It would be expected that once the dust has settled, high schools will be sending students to colleges with similar backgrounds because of the standardized expectations.

Types of Secondary School Courses

The new curriculum for secondary school is organized into several types of courses. The new system of courses is intended to enable students to choose courses that are suited to their strengths, interests, destinations and goals. In Grades 9 and 10, three types of courses are offered: academic, applied, and open. Courses in Grades 11 and 12 are designed to prepare students for a post secondary destination – that is, for university, college, apprenticeship training, or the workplace.

Applied vs. Academic (Grades 9 and 10)

The two types of courses differ in the balance among essential concepts and additional material, and in the balance among theory and application. Specifically, the types of concepts discussed are either very theoretical or very practical, with some common ground in the middle. (This is further illustrated in the *Practical-Theoretical Continuum*)

Types of Courses in Grades 11 and 12 (Destination Based)

In Grades 11 and 12, students will choose from among four destination-related course types: *university preparation, university/college preparation, college preparation,* and *workplace preparation*. Open courses are also offered in Grades 11 and 12, in other disciplines, but not mathematics. Students will make their choices on the basis of their interests, achievement, and career goals. All university preparation courses, university/college preparation courses, college preparation courses, and workplace preparation courses have been developed in collaboration with representatives of universities, colleges, apprenticeship programs, or the business community, as appropriate, and are designed to enable students to meet the entrance requirements of post-secondary institutions or apprenticeship or other training programs, or the expectations of employers in the workplace.

College preparation courses are designed to equip students with the knowledge and skills they need to meet the admission requirements for college, apprenticeship or other training programs.

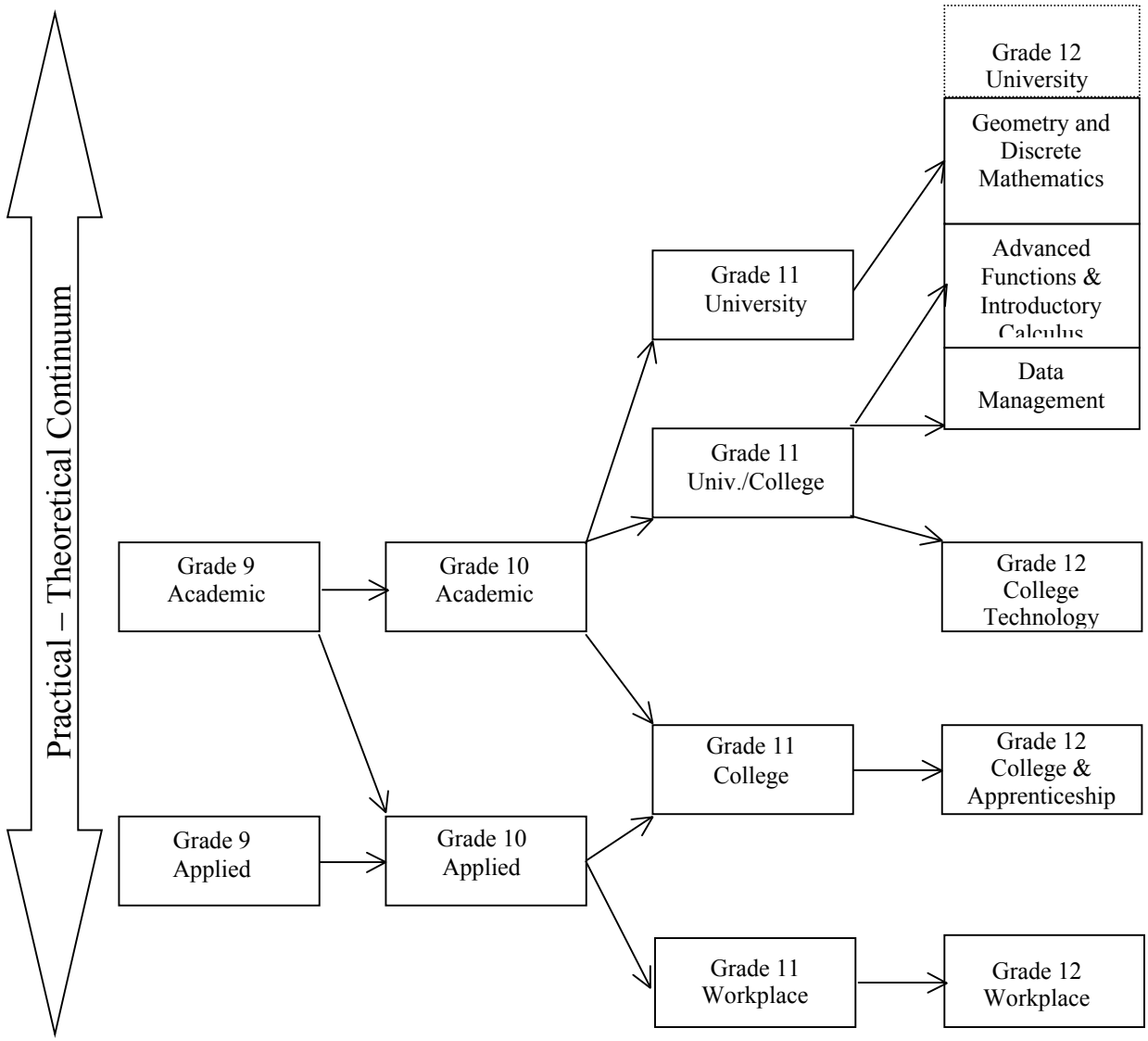
Transfer Courses

Transfer courses are made available in Grades 10 and 11 to offer students a means of transferring from one type of course in a particular subject to another if their interests and postsecondary goals change during the school year.

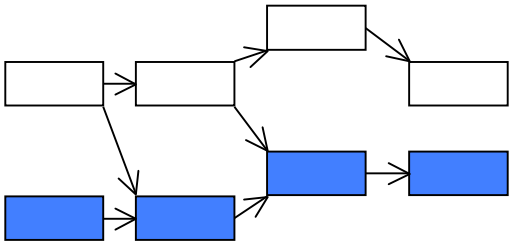
Prerequisites for Grade 11 and 12 courses are specified in the curriculum policy documents for the various disciplines. A student who has completed a course of one type in a particular subject and grade that does not meet a stated prerequisite for a course in the same subject in the next grade may take a transfer course – that is, a partial-credit course that bridges the gap between the course completed and the course of the type designated as a prerequisite. Transfer courses enable students to achieve the expectations not covered in one course type but required for entry into a course of a different type in the next grade. For example, the prerequisite for the Grade 11 University preparation course in Math is the Grade 10 academic course in Math. A student who has taken the applied Math course in Grade 10 and who decides to enter the university preparation course in grade 11 may do so by taking a transfer course.

Math Course Paths for College-bound Students

The following flowchart represents the connection between math courses at the secondary school level. The practical-theoretical continuum indicates that courses near the top of the diagram are the most theoretical while those at the bottom are the most practical and other courses along the continuum are a mixture of practical and theoretical. The four typical paths through this flowchart are explained following the flowchart, as are the course expectations of the two grade 12 college destination math courses.

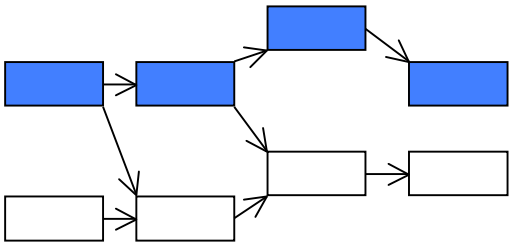


Path 1 - Grade 12 College and Apprenticeship Math



These students enter high school with the goal of either proceeding to a college program, without a science or technology focus, such as fashion design or marketing, or heading to work directly from high school. These students stay in the more practical applied level courses for grades nine and ten, and the college level courses in grades eleven and twelve. Their final math course is the Grade 12, College and Apprenticeship Math, which has less emphasis on theory and more on modeling and applications than the other grade 12 courses. The expectations of this course will be detailed in the next section of this report.

Path 2 - Grade 12 College Technology Math

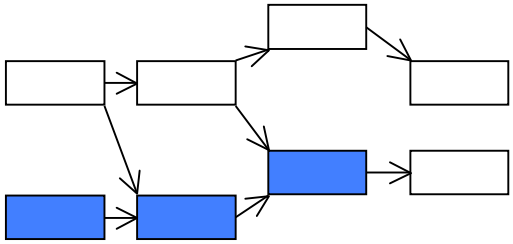


These students have an intended destination of university or possibly college when they arrive in secondary school. After the grade 11 University / College course students change from a university path to a college one, either because their intended field of interest is best served at the college level or because their academic strengths prevent them from continuing in math at the 12 University level. For these students their final math course is the Grade 12 College Technology Math that offers a balance of theory and practical applications in a wide variety of topics.

Refer to the section on course expectations for more detail on the content of this grade 12 course.

Note: A small group of students will take the *College Technology Math* prior to taking the University level Calculus course, and would fit in both paths 2 and 4.

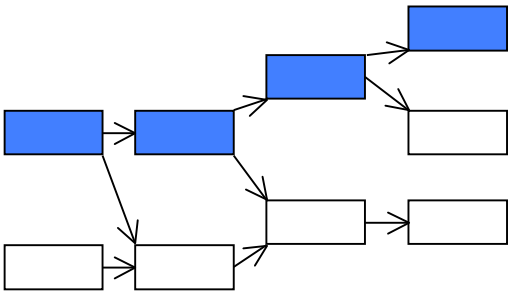
Path 3 - Grade 11 College Math



A very small number of students will enter college programs without a grade 12-math course. Since only three math courses are required for graduation, some students will not take math in grade 12. Typically these students will be following the same path as the Group 1 students.

Currently college programs such as law clerk, theatre arts and office administration have no grade 12 math requirements.

Path 4 - Grade 12 University Level Math Courses



Although not the primary focus of this study, there are three different math courses offered at the Grade 12 University level: Advanced Functions and Calculus, Data Management, and Algebra and Discrete Mathematics. Some students will continue in the academic and university level math courses in order to keep a variety of options open and will enter college programs with one or more math courses at the Grade 12 University level. These students experience a much more theoretical approach to mathematics than students in the other three groups. As this group will be small, the course expectations of the university level courses are not included in this presentation but they can be found in the various Ministry curriculum documents.

College Preparation Courses

The Grade 11 college preparation course, Mathematics of Personal Finance, includes a powerful blend of topics that will equip students not only for many college destinations but also for their adult lives. In the strand called Models of Exponential Growth, students explore applications and properties of exponential functions. In the Applications of Compound Interest and Annuities strand, students undertake an in-depth study of the effect of compound interest on saving, borrowing, and investing. In the Personal Financial Decisions strand, students explore mathematical decision making related to choices about vehicle purchase, accommodation, and careers.

The Grade 12 college preparation course College and Apprenticeship Mathematics consists of three strands. In the Applications of Statistics strand, students acquire critical skills in the area of information collection, analysis, and evaluation. In the strand called Applications of Geometry, Measurement, and Trigonometry, students apply geometric properties to the creation of plans and scale models, solve measurement problems in both the metric and the imperial systems, and solve problems involving trigonometry in triangles. Finally, in the strand called Analysis of Mathematical Models, students consolidate their skills in analyzing and interpreting graphical models and in manipulating key algebraic expressions.

The Grade 12 college preparation course Mathematics for College Technology is intended for students planning to study mathematics-focused programs at college, such as diploma technology programs. Its three strands build on the function base established in Grade 11. In the strand called Polynomial Functions and Inverse Proportionality, students investigate and apply properties of polynomial functions, solve problems involving applications of inverse proportionality, and investigate the properties of reciprocal functions. In the strand Exponential and Logarithmic Functions, students investigate and apply properties of exponential and logarithmic functions. Finally, in the strand Applications and Consolidation, students analyze models of a variety of functions, explore applications of piecewise-defined functions, solve linear-quadratic systems, and consolidate key manipulation and communication skills.

Overall Course Expectations

Each of the grade 12 College level math courses has been divided into strands (course themes) where the overall course expectations are given. Where possible these expectations are separated into those representing new course material and those representing an extension of expectations in the prerequisite courses. See Appendix C for a list of the detailed course expectations for each of these courses.

Mathematics for College Technology, Grade 12, College Preparation, MCT4C

This course equips students with the mathematical knowledge and skills needed for entry into college technology programs. Students will investigate and apply properties of polynomial, exponential, and logarithmic functions; solve problems involving inverse

proportionality; and explore the properties of reciprocal functions. They will also analyze models of a variety of functions, solve problems involving piecewise-defined functions, solve linear-quadratic systems, and consolidate key manipulation and communication skills.

New course material	Extension of previous material
Polynomial Functions and Inverse Proportionality	
• determine, through investigation, the characteristics of the graphs of polynomial functions of various degrees	• demonstrate facility in the algebraic manipulation of polynomials
• demonstrate an understanding of inverse proportionality	• determine, through investigation, the key properties of reciprocal functions
Exponential and Logarithmic Functions	
• Define and apply logarithmic functions	• demonstrate an understanding of the nature of exponential growth and decay
Applications and Consolidation	
• analyze and interpret models of piecewise-defined functions drawn from a variety of applications	• analyze models of linear, quadratic, polynomial, exponential, or trigonometric functions drawn from a variety of applications
• solve linear-quadratic systems and interpret their solutions within the contexts of applications	• demonstrate facility in carrying out and applying key manipulation skills

College and Apprenticeship Mathematics, Grade 12, College Preparation MAP4C

This course equips students with the mathematical knowledge and skills they will need in many college programs. Students will use statistical methods to analyze problems; solve problems involving the application of principles of geometry and measurement to the design and construction of physical models; solve problems involving trigonometry in triangles; and consolidate their skills in analyzing and interpreting mathematical models.

New course material	Extension of previous material
Applications of Statistics	
• collect, analyze, and evaluate data involving one variable	
• collect, analyze, and evaluate data involving two variables	
• analyze significant problems or issues, using statistics	
• evaluate the validity of the use of statistics in the media	
Applications of Geometry, Measurement, and Trigonometry	
• demonstrate an understanding of the relationship between three-dimensional objects and their two-dimensional representations	• solve problems involving trigonometry in triangles
• solve problems involving measurement	
Analysis of Mathematical Models	
• interpret and analyze data given in a variety of forms	• interpret and analyze given graphical models
	• interpret and analyze given formulaic models

The Role of Technology in the Curriculum

Another very visible part of the new curriculum is the integration of many different types of technology into the classroom. Increasing reliance on computers, telecommunication networks, and information technologies in society and the workplace makes it essential for students to become computer literate and to develop "information literacy" skills. Information literacy is the ability to access, select, gather, critically evaluate, create, and communicate information, and to use the information obtained to solve problems and make decisions. In preparation for further education, employment, citizenship, and lifelong learning, students must be capable of deriving meaning from information by using a wide variety of information literacy skills.

Technology helps to make students more powerful learners by giving them the means to explore mathematical concepts more effectively. In the time gained by using technology, students can study fundamental ideas in greater depth, develop higher skill levels, and explore more applications.

Various forms of technology have application in many different areas of mathematics learning. Calculators save students time in performing complex arithmetic calculations. Graphing utilities enable students to explore properties of the graphs of functions. Statistical software allows students to collect and analyze data effectively and quickly. Dynamic geometry software allows students to visualize spatial relationships, to test hypotheses, and to investigate the properties of loci. The use of technology in learning and doing mathematics also gives students excellent opportunities to develop their abilities in algorithmic thinking, for example, by creating templates in spreadsheets or by writing sequences of instructions in application programs as part of a problem-solving process. Specific software that the new curriculum students are receiving instructions on are: *TI-83 Graphing Calculators: Applications & Peripherals, Fathom, Spreadsheets, and Geometer's Sketchpad.*

The presence of technology as part of learning mathematics makes many new things possible, but it also places increasing importance on the ability of students to make mental judgements about expected results. For example, the student who uses a calculator to perform an arithmetic calculation should have the habit of using estimation to judge the reasonableness of the answer produced. Similarly, the student who produces a graph using technology should be capable of creating a mental approximation of the graph as a verification of the image on the screen.

Conclusions

In summary, the students who are proceeding into college will be coming with the experiences of hands on exploration, independent inquiry, with a strong emphasis on technology throughout the curriculum. Many of these students will have made the decision to proceed to college very early in their high school careers and will be focused on their goal. Others will determine their destination much later in high school. The new curriculum differs significantly from the old curriculum in that the levels (general,

applied) are not the same. The new courses are distinguished by the approach used to teach the material, theory versus application rather than by the abilities of the student. This approach of scaling the math courses by their practical applications and their theoretical work is far more advantageous. For example, math for college apprenticeship is a project oriented course, affording students the opportunity to work in groups on a regular basis. Math for college technology, on the other hand, combines theory and applications for those students entering college programs that have a definite math focus.

Appendix A:
Mathematics Course Prerequisites – College Programs

Gr. 12 College Math: (MCT 4C) - Mathematics for College Technology

Take this course as a prerequisite for these Community College courses:

• Computer Engineering Technology	• Manufacturing Engineer
• Electrical Engineering Technician	• Manufacturing Technician
• Electronic Engineering	• Science Lab Technician
• Computer Programmer	• Civil Engineering Technology
• Computer Analyst	• Architectural Technology
• Computer Systems Technician	

Gr. 12 College Math: (MAP 4C) - College and Apprenticeship* Mathematics

Take this course as a prerequisite for these Community College Courses:

• Accounting	• Dental Assistant
• Marketing	• Medical Radiation Technology
• Financial Services	• Paramedic
• Graphic Design	• Pharmacy Assistant
• Construction Engineering Technician	• Respiratory Therapy
• Interior Design	• Horticultural and Landscape Technician
• Food & Beverage Management	• Fashion Design

* *Many apprenticeships require that students study courses at college that may include mathematics*.

Community College Courses that have NO Grade 12 Mathematics prerequisites:

• Law Clerk	• Theatre Arts
• Broadcasting	• Child & Youth Worker
• Radio	• Early Childhood Education
• Television	• Law and Security Administration
• Fine Art	• Horticultural & Landscape Technician
• Food and Beverage Management	• Travel & Tourism
• Office Administration	• Hotel Management

Appendix B
Useful Websites and Sources of Information

Ministry of Education curriculum documents:
http://www.edu.gov.on.ca/eng/document/curricul/secondary/grade1112/math/math.html#top

Course Profile documents:
http://www.curriculum.org/occ/

Appendix C
Detailed Course Expectations

Mathematics for College Technology, Grade 12, College Preparation, MCT4C

Polynomial Functions and Inverse Proportionality

Overall Expectations

PFV.01 · determine, through investigation, the characteristics of the graphs of polynomial functions of various degrees;

PFV.02 · demonstrate facility in the algebraic manipulation of polynomials;

PFV.03 · demonstrate an understanding of inverse proportionality;

PFV.04 · determine, through investigation, the key properties of reciprocal functions.

Specific Expectations

Investigating the Graphs of Polynomial Functions

PF1.01 – determine, through investigation, using graphing calculators or graphing software, various properties of the graphs of polynomial functions (e.g., determine the effect of the degree of a polynomial function on the shape of its graph; the effect of varying the coefficients in the polynomial function; the type and the number of x-intercepts; the behaviour near the x-intercepts; the end behaviours; the existence of symmetry);

PF1.02 – describe the nature of change in polynomial functions of degree greater than two, using finite differences in tables of values;

PF1.03 – compare the nature of change observed in polynomial functions of higher degree with that observed in linear and quadratic functions;

PF1.04 – sketch the graph of a polynomial function whose equation is given in factored form;

PF1.05 – determine an equation to represent a given graph of a polynomial function, using methods appropriate to the situation (e.g., using the zeros of the function; using a trial-and-error process on a graphing calculator or graphing software; using finite differences).

Manipulating Algebraic Expressions

PF2.01 – demonstrate an understanding of the remainder theorem and the factor theorem;

PF2.02 – factor polynomial expressions of degree greater than two, using the factor theorem;

PF2.03 – determine, by factoring, the real or complex roots of polynomial equations of degree greater than two;

PF2.04 – determine the real roots of non-factorable polynomial equations by interpreting the graphs of the corresponding functions, using graphing calculators or graphing software;

PF2.05 – write the equation of a family of polynomial functions, given the real or complex zeros [e.g., a polynomial function having non-repeated zeros 5, –3, and –2 will be defined by the equation $f(x) = (x – 5)(x + 3)(x + 2)$, for $k \in \mathbf{R}$;

PF2.06 – describe intervals and distances, using absolute-value notation;

PF2.07 – solve factorable polynomial inequalities;

PF2.08 – solve non-factorable polynomial inequalities by graphing the corresponding functions, using graphing calculators or graphing software and identifying intervals above and below the x-axis.

Understanding Inverse Proportionality

PF3.01 – construct tables of values, graphs, and formulas to represent functions of inverse proportionality derived from descriptions of realistic situations (e.g., the time taken to complete a job varies inversely as the number of workers; the intensity of light radiating equally in all directions from a source varies inversely as the square of the distance between the source and the observer);

PF3.02 – solve problems involving relationships of inverse proportionality.

Determining the Key Properties of Reciprocal Functions

PF4.01 – sketch the graph of the reciprocal of a given linear or quadratic function by considering the implications of the key features of the original function as predicted from its equation (e.g., such features as the domain, the range, the intervals where the function is positive or negative, the intervals where the function is increasing or decreasing, the zeros of the function);

PF4.02 – describe the behaviour of a graph near a vertical asymptote;

PF4.03 – identify the horizontal asymptote of the graph of a reciprocal function by examining the patterns in the values of the given function.

Exponential and Logarithmic Functions

Overall Expectations

ELV.01 · demonstrate an understanding of the nature of exponential growth and decay;

ELV.02 · define and apply logarithmic functions.

Specific Expectations

Understanding the Nature of Exponential Growth and Decay

EL1.01 – identify, through investigations, using graphing calculators or graphing software, the key properties of exponential functions of the form a^x ($a > 0$, $a \neq 1$) and their graphs (e.g., the domain is the set of the real numbers; the range is the set of the positive real numbers; the function either increases or decreases throughout its domain; the graph has the x-axis as an asymptote and has y-intercept = 1);

EL1.02 – describe the graphical implications of changes in the parameters a, b, and c in the equation $y = ca^x + b$;

EL1.03 – compare the rates of change of the graphs of exponential and non-exponential functions (e.g., those with equations $y = 2x$, $y = x^2$, $y = x^{\frac{1}{2}}$, and $y = 2^x$);

EL1.04 – describe the significance of exponential growth or decay within the context of applications represented by various mathematical models (e.g., tables of values, graphs, equations);

EL1.05 – pose and solve problems related to models of exponential functions drawn from a variety of applications, and communicate the solutions with clarity and justification.

Defining and Applying Logarithmic Functions

EL2.01 – define the logarithmic function $\log_a x$ ($a > 1$) as the inverse of the exponential function a^x, and compare the properties of the two functions;

EL2.02 – express logarithmic equations in exponential form, and vice versa;

EL2.03 – simplify and evaluate expressions containing logarithms, using the laws of logarithms;

EL2.04 – solve simple problems involving logarithmic scales (e.g., the Richter scale, the pH scale, the decibel scale).

Applications and Consolidation

Overall Expectations

ACV.01 · analyze models of linear, quadratic, polynomial, exponential, or trigonometric functions drawn from a variety of applications;

ACV.02 · analyze and interpret models of piecewise-defined functions drawn from a variety of applications;

ACV.03 · solve linear-quadratic systems and interpret their solutions within the contexts of applications;

ACV.04 · demonstrate facility in carrying out and applying key manipulation skills.

Specific Expectations

Analysing Models of Functions

AC1.01 – determine the key features of a mathematical model (e.g., an equation, a table of values, a graph) of a function drawn from an application;

AC1.02 – compare the key features of a mathematical model with the features of the application it represents;

AC1.03 – predict future behaviour within an application by extrapolating from a given model of a function;
AC1.04 – pose questions related to an application and use a given function model to answer them.

Analysing and Interpreting Models of Piecewise-Defined Functions

AC2.01 – demonstrate an understanding that some naturally occurring functions cannot be represented by a single formula (e.g., the temperature at a particular location as a function of time);
AC2.02 – graph a piecewise-defined function, by hand and by using graphing calculators or graphing software;
AC2.03 – analyze and interpret a given mathematical model of a piecewise-defined function, and relate the key features of the model to the characteristics of the application it represents;
AC2.04 – make predictions and answer questions about an application represented by a graph or formula of a piecewise-defined function;
AC2.05 – determine the effects on the graph and formula of a piecewise-defined function of changing the conditions in the situation that the function represents.

Solving Linear-Quadratic Systems

AC3.01 – determine the key properties of a linear function or a quadratic function, given the equation of the function, and interpret the properties within the context of an application;
AC3.02 – solve linear-quadratic systems arising from the intersections of the graphs of linear and quadratic functions;
AC3.03 – interpret the solution(s) to a linear- quadratic system within the context of an application.

Consolidating Key Skills

AC4.01 – perform numerical computations effectively, using mental mathematics and estimation;
AC4.02 – solve problems involving ratio, rate, and percent drawn from a variety of applications;
AC4.03 – solve problems involving trigonometric ratios in right triangles and the sine and cosine laws in oblique triangles;
AC4.04 – demonstrate facility in using manipulation skills related to solving linear, quadratic, and polynomial equations, simplifying rational expressions, and operating with exponents.

College and Apprenticeship Mathematics, Grade 12, College Preparation MAP4C

Applications of Statistics

Overall Expectations

ASV.01 · collect, analyze, and evaluate data involving one variable;
ASV.02 · collect, analyze, and evaluate data involving two variables;
ASV.03 · analyze significant problems or issues, using statistics;
ASV.04 · evaluate the validity of the use of statistics in the media.

Specific Expectations

Collecting, Analysing, and Evaluating Data Involving One Variable

AS1.01 – determine appropriate methods for collecting, storing, and retrieving, from primary or secondary sources, data involving one variable;
AS1.02 – design questionnaires for gathering data through surveys, giving consideration to possible sources of bias;
AS1.03 – demonstrate an understanding of the distinction between the terms *population* and *sample*;
AS1.04 – choose from and apply a variety of sampling techniques (e.g., random, stratified);
AS1.05 – represent data in appropriate graphical forms (e.g., histograms, bar graphs), using technology;
AS1.06 – identify and describe properties of common distributions of data (e.g., normal, bimodal, exponential, skewed);
AS1.07 – calculate the mean, median, mode, range, variance, and standard deviation of a data set, using standard statistical notation and technology;
AS1.08 – describe the significance of results drawn from analyzed data (e.g., the shape of the distribution, the mean, the standard deviation);
AS1.09 – make and justify statements about a population on the basis of sample data.

Collecting, Analysing, and Evaluating Data Involving Two Variables

AS2.01 – determine appropriate methods for collecting, storing, and retrieving, from primary or secondary sources, data involving two variables;
AS2.02 – construct a scatter plot to represent data, using technology;
AS2.03 – determine an equation of a line of best fit, using the regression capabilities of graphing technology;
AS2.04 – calculate and interpret the correlation coefficient, using appropriate technology;
AS2.05 – describe possible misuses of regression (e.g., use with too small a sample, use without considering the effect of outliers, inappropriate extrapolation);
AS2.06 – describe the relationship between two variables suggested by a scatter plot (e.g., no relationship, a positive correlation, a negative correlation);
AS2.07 – make and justify statements about a population on the basis of sample data.

Analysing Problems

AS3.01 – collect, organize, and analyze data to address problems or issues, and calculate relevant statistical measures;
AS3.02 – formulate a summary conclusion to a problem or an issue, by synthesizing interpretations of individual statistical measures;
AS3.03 – formulate extending questions related to the conclusion reached in the investigation of a problem or an issue;
AS3.04 – communicate the process used and the conclusions reached in the investigation of a problem or an issue, using appropriate mathematical forms (e.g., oral and written explanations, tables, graphs, formulas).

Evaluating Validity

AS4.01 – explain the use and misuse in the media of graphs and commonly used statistical terms (e.g., *percentile*), and expressions (e.g., *19 times out of 20*);
AS4.02 – assess the validity of conclusions made on the basis of statistical studies, by analysing possible sources of bias in the studies (e.g., sampling bias);

AS4.03 – explain the meaning, and the use in the media, of indices based on surveys (e.g., the consumer price index).

Applications of Geometry, Measurement, and Trigonometry

Overall Expectations

AGV.01 · demonstrate an understanding of the relationship between three-dimensional objects and their two-dimensional representations;
AGV.02 · solve problems involving measurement;
AGV.03 · solve problems involving trigonometry in triangles.

Specific Expectations

Understanding Two-Dimensional and Three-Dimensional Shapes

AG1.01 – identify, through observation and measurement, the uses of geometric shapes and the reasons for those uses, in a variety of applications (e.g., product design, architecture, fashion);
AG1.02 – represent three-dimensional objects in a variety of ways (e.g., front, side, and top views; perspective drawings; scale models), using concrete materials and design or drawing software;
AG1.03 – create nets, plans, and patterns from physical models related to a variety of applications (e.g., fashion design, interior decorating, building construction), using design or drawing software;
AG1.04 – design and construct physical models of things (e.g., structures, equipment, furniture), satisfying given constraints and using concrete materials, design software, or drawing software.

Solving Problems Involving Measurement

AG2.01 – solve problems related to the perimeter and area of plane figures, and the surface area and volume of prisms, pyramids, cylinders, spheres, and cones, including problems involving combinations of these objects;
AG2.02 – demonstrate accuracy and precision in working with metric measures;
AG2.03 – demonstrate an understanding of the use of the imperial system in a variety of applications (e.g., bolt and screw sizes; tool sizes; quantities of soil, water, or cement);
AG2.04 – demonstrate a working knowledge of the measurement of length and area in the imperial system, in relation to applications (e.g., design, construction);
AG2.05 – perform required conversions between the imperial system and the metric system, as necessary within projects and applications;
AG2.06 – use calculators effectively in solving problems involving measurement, and judge the reasonableness of the answers produced.

Solving Problems Involving Trigonometry in Triangles

AG3.01 – solve problems involving trigonometry in right triangles;
AG3.02 – demonstrate an understanding of the signs of the sine, cosine, and tangent of obtuse angles;
AG3.03 – determine side lengths and angle measures in oblique triangles, using the cosine law and the sine law, and solve related problems;
AG3.04 – identify applications of trigonometry in occupations and in post-secondary programs related to the occupations.

Analysis of Mathematical Models

Overall Expectations

MMV.01 · interpret and analyze given graphical models;
MMV.02 · interpret and analyze given formulaic models;
MMV.03 · interpret and analyze data given in a variety of forms.

Specific Expectations

Interpreting and Analysing Given Graphical Models

MM1.01 – interpret a given linear, quadratic, or exponential graph to answer questions, using language and units appropriate to the context from which the graph was drawn;

MM1.02 – interpret the rate of change and initial conditions (i.e., the slope and *y*-intercept) of a linear model given within a context;
MM1.03 – make and justify a decision or prediction and discuss trends based on a given graph;
MM1.04 – describe the effect on a given graph of new information about the circumstances represented by the graph (e.g., describe the effect of a significant change in population on a graph representing the size of the population over time);
MM1.05 – communicate the results of an analysis orally, in a written report, and graphically.

Interpreting and Analysing Given Formulaic Models

MM2.01 – evaluate any variable in a given formula drawn from an application by substituting into the formula and using the appropriate order of operations on a scientific calculator;
MM2.02 – construct (e.g., combine or modify) formulas to solve multi-step problems in particular situations (e.g., determine the amount of paint required to paint two coats on a large cylindrical water tank);
MM2.03 – rearrange a formula to isolate any variable in it (e.g., to determine the values of a variable in a formula, using a spreadsheet);
MM2.04 – judge the reasonableness of answers to problems;
MM2.05 – demonstrate mastery of key algebraic skills, including the ability to solve linear equations, to solve systems of linear equations, to graph a linear function from its equation, and to determine the slope and intercepts of a linear function from its equation;
MM2.06 – factor expressions of the form $ax^2 + bx + c$;
MM2.07 – solve quadratic equations by factoring.

Interpreting and Analysing Data Given in a Variety of Forms

MM3.01 – retrieve information from various sources (e.g., graphs, charts, spreadsheets, schedules);
MM3.02 – identify options that meet certain criteria, using more than one chart, spreadsheet, or schedule (e.g., the schedules of connecting flights; the spreadsheets of mortgage- payment plans);
MM3.03 – make informed decisions, using data provided in chart, spreadsheet, or schedule format and taking into account personal needs and preferences;
MM3.04 – enter data or a formula into a graphing calculator and retrieve other forms of the model (e.g., enter data and retrieve a scatter graph or a table of values; enter a formula and retrieve a table of values or the graph of a function).