Cambridge Pre-U Teacher Guide

Cambridge International Level 3 Pre-U Certificate in **MATHEMATICS** **FURTHER MATHEMATICS**

Available for teaching from September 2008

UNIVERSITY *of* CAMBRIDGE
International Examinations

Cambridge Pre-U

Teacher Guide

Mathematics (9794) and Further Mathematics (9795)

Cambridge International Level 3 Pre-U Certificate in Mathematics and Further Mathematics (Principal)

For use from 2008 onwards

Cambridge International Level 3 Pre-U Certificate

Mathematics

9794

Further Mathematics

9795

Contents

Introduction

The aim of this guide is to provide a detailed annotation of the syllabuses which will give a clear indication of the depth of coverage to which topics should be approached, with links to further resources for teachers.

It is hoped that the materials provided will give Centres useful additional material to that provided in the syllabuses, which will over time improve and enhance the delivery and approach to the syllabuses within a Centre.

Other features which will be added at a later date will include annotated exemplar candidate work assignments and standards exemplification. In the meantime, a Trialling Report is available for teachers with examples of candidates' responses to the first sample papers and examiners' comments.

Additionally, teachers are reminded of the Pre-U Online Community pages on the website where new material will be posted and opportunities offered for exchanging ideas with other teachers.

Cambridge Pre-U Diploma

Not all Centres will be aiming for the Diploma at the outset. However, two of its core elements – the Global Perspectives course and Independent Research Report (GPR) – are intended to be taught as successive one-year courses and can be pursued independently of the full Diploma. Global Perspectives demands a 1500 word essay and a 15 minute presentation as well as assessing critical analysis skills through a short examination. The Independent Research Report (IRR) is a 4500–5000 word written report. Both of these Pre-U core elements will help to develop the research and presentation skills so useful for subject-based activities for independent learning in year two of the subject course. The IRR could focus upon an area of interest generated by one of the Principal subjects taken by the candidate. The two core components can be certified as Cambridge Pre-U Certificate in Global Perspectives and Independent Research. It can be a stand alone certificate and when combined with three Cambridge Pre-U Principal subjects, it completes the requirement to be awarded the full Cambridge Pre-U Diploma.

Introduction to the Cambridge Pre-U Mathematics and Further Mathematics Syllabuses

The Cambridge Pre-U Mathematics syllabus is a two year course designed to prepare candidates for further study in Mathematics or numerate disciplines. Candidates study Pure Mathematics in depth together with applications in both Probability and Mechanics. The applications have been chosen in order to give candidates the opportunity to apply their knowledge of pure mathematical techniques in a practical context. It is hoped that candidates following the Cambridge Pre-U Mathematics course will develop a holistic approach to the subject, with an appreciation for how topics interlink.

Assessment takes place at the end of the course and comprises two 3 hour papers. Topics from the Pure Mathematics content will be assessed across both papers to reflect the coherent nature of the subject. Consequently it is essential that candidates are made aware of how the material they are studying inter-relates. On each paper approximately two thirds of the marks available will be for Pure Mathematics and the other third of the marks will be for the applications of mathematics (Probability on Paper 1 and Mechanics on Paper 2).

The Cambridge Pre-U Further Mathematics course builds on the material in the Mathematics course, giving candidates the opportunity to learn more advanced mathematical techniques. Candidates study Pure Mathematics in depth together with applications in both Probability and Mechanics. The applications have been chosen in order to give candidates the opportunity to apply their knowledge of pure mathematical techniques in a practical context. Whilst there are many possible routes to A Level Further Mathematics, candidates who have completed the Cambridge Pre-U Further Mathematics course will all have studied a common syllabus. Assessment takes place at the end of the course and comprises two 3 hour papers: Paper 1 – Further Pure Mathematics and Paper 2 – Further Applications of Mathematics.

It is recognised that there are many benefits of using graphic calculators and computers in the teaching of mathematics. However, given the wide range of products on the market and the fact that some candidates may not have access to such technology, for the purposes of the examinations, candidates will only be permitted to use scientific calculators.

Mapping the Cambridge Pre-U Mathematics Syllabus to A Level Content

Candidates studying Cambridge Pre-U Mathematics will cover almost all of the material from Core 1 to 4, irrespective of specification. In some cases greater depth of understanding will be required and this will be highlighted in the relevant sections of the Teacher Guide. They will also have an introduction to Complex Numbers, a topic usually encountered in FP1. The Numerical Analysis content required for Pre-U Mathematics includes the Newton-Raphson method, which also appears in Further Mathematics for some A Level specifications. Candidates will also study some topics from S1, S2, M1 and M2, depending on A Level specification. There is no Decision Mathematics in the Cambridge Pre-U Mathematics syllabus.

Topic	OCR	OCR (MEI)	AQA	EDEXCEL
Numerical Analysis				
Change of sign methods	C3	C3	C3	C3
x = f(x) iteration	C3	C3	C3	C3
Newton-Raphson	FP2	C3	FP1	FP1
Complex Numbers				
Definition of complex numbers and associated arithmetic	FP1	FP1	FP1	FP1
Representation in the Argand diagram	FP1	FP1	FP2	FP1
Complex roots of quadratic equations	FP1	FP1	FP1	FP1
Probability				
Use of measures of central tendency and variance to describe data	S1	S1	S1	S1
Calculation of mean and standard deviation	S1	S1	S1	S1
Definition of outliers	S1	S1	N/A	S1
Regression lines for bivariate data	S1	S2	S1	S1
Pearsons' Product Moment Correlation Coefficient	S1	S2	S1	S1
Probability Laws	S4	S1	S1	S1
Discrete random variables including calculation of expectation and variance	S1	S1	S2	S1
Binomial Distribution	S1	S1	S1	S2
Geometric Distribution	S1	N/A	N/A	N/A
Normal Distribution	S2	S2	S1	S1
Mechanics				
Kinematics of motion in a straight line	M1	M1	M1	M1/M2
Force and Equilibrium	M1	M1	M1	M1
Friction	M1	M2	M1	M1
Newton's Laws of Motion	M1	M1	M1	M1
Linear Momentum and Impulse	M1	M2	M1	M1
Motion of a Projectile	M2	M1	M1	M2

Elaboration on the Content of the Cambridge Pre-U Mathematics Syllabus

It is expected that candidates will have a secure grounding in the basic principles of mathematics consistent with the material covered in GCSE, IGCSE or International O Level specifications. In particular they should be familiar with the solution of linear equations and inequalities, pairs of linear simultaneous equations and trigonometry in the context of right angled triangles.

Pure Mathematics

The Assessment Objectives state that candidates 'manipulate mathematical expressions accurately' (AO1); and 'construct rigorous mathematical arguments and proofs through the use of precise statements and logical deduction, including extended arguments for problems presented in unstructured form' (AO2). It is intended that the linear nature of the Cambridge Pre-U course gives candidates time to develop their mathematical communication skills in order to be able to tackle a wide range of problems independently. The most able candidates are likely to develop an appreciation for the elegance of a logical mathematical argument in which there is little or no redundancy.

Quadratics

The solution of quadratic equations is central to much of the mathematics encountered at this level and beyond. Candidates need to be familiar with factorising, completing the square and the use of the quadratic formula. The quadratic formula is not given to candidates in the formula book so must be recalled.

The quadratic equation $ax^2 + bx + c = 0$ has roots $x = \dfrac{-b \pm \sqrt{(b^2 - 4ac)}}{2a}$

Candidates should have an appreciation of when each method is appropriate and how factorising and completing the square relate to the graphical representation of quadratics. Given that candidates following the Pre-U Mathematics syllabus will gain a basic appreciation of complex numbers this can usefully be linked to the study of quadratics when discussing. Candidates should also be able to recognise equations that are quadratic in some other function, for example in trigonometry.

Candidates are expected to be able to manipulate expressions in terms of surds and should understand what is meant by an exact answer and why it might be efficient to leave an answer in such a form.

Algebra
In addition to algebraic methods for the solution of inequalities, graphical methods may also be used as suggested in the mark scheme for Specimen Paper 2, question 9. In all cases candidates need to be aware of whether their solutions make sense and a graph is often a good way to examine the validity of a result, even if it has been obtained algebraically.

Candidates should appreciate that polynomials occur in many situations and that the ability to identify possible factors and divide polynomials may be required in a range of contexts.

It should be recognised that it may be necessary to use partial fractions in a range of situations including calculus applications and when using the general binomial expansion.

Functions
It is intended that candidates become familiar with the language of functions and those circumstances under which it is appropriate to talk about inverse functions. When considering the relationship between the graphs of a function and its inverse, candidates should understand how the gradients of the two graphs are related. In particular, candidates should appreciate the relationship between $y = e^x$ and $y = \ln x$ as inverse functions and also how the inverse trigonometric functions $\sin^{-1}x$, $\cos^{-1}x$ and $\tan^{-1}x$ relate to $\sin x$, $\cos x$ and $\tan x$ as highlighted in the trigonometry section of the syllabus.

Coordinate Geometry
Whilst it is recognised that the use of a sketch gives insight into how a problem may be approached, the solutions to problems in coordinate geometry should be obtained by calculation and not by accurate drawing.

Candidates should be aware of the basic properties of tangents and circles (e.g. the tangent is perpendicular to the radius, tangents from a common point to a circle are of equal length) and simple angle properties of circles (e.g. the angle subtended from a diameter is a right angle). They should be able to use the occurrence of repeated roots to solve problems relating to tangents (e.g. Specimen Paper 1, question 7)

The equation for a circle is not given, but candidates should be familiar with the following forms and be able to switch between them:
For a circle of centre (h, k) and radius r, the equation of a circle is given by

$$(x - h)^2 + (y - k)^2 = r^2 \quad \text{or} \quad x^2 - 2hx + y^2 - 2ky + h^2 + k^2 - r^2 = 0$$

In addition, candidates should understand how the gradient of a line may be interpreted in terms of the angle between the line and the x-axis as seen in Specimen paper 1, question 10. This also has links to the concept of argument when studying complex numbers.

Circular Measure
Candidates should be able to work in both degrees and radians and be able to identify when it is appropriate to leave answers as multiples of π. In particular they should be able to recall the radian equivalents of 30°, 45°, 60° and related angles, together with the associated values for sine, cosine and tangent.

Trigonometry
In addition to the graphs of sine, cosine and tangent, candidates are expected to be familiar with the graphs of cosecant, secant and cotangent which are less well known.

Whilst cosine rule is given in the formula book, the following results are not and must be learned by the candidates:

Sine rule: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Area of a triangle formula: ½ ab sin C

Likewise, the following identities and double angle formulae must be recalled:

$\sin^2 x + \cos^2 x = 1$, $\sec^2 x = 1 + \tan^2 x$ and $\operatorname{cosec}^2 x = 1 + \cot^2 x$

$$\frac{\sin x}{\cos x} = \tan x$$

$\sin 2x = 2 \sin x \cos x$
$\cos 2x = \cos^2 x - \sin^2 x = 2\cos^2 x - 1 = 1 - 2\sin^2 x$

$$\tan 2x = \frac{2 \tan x}{1 - \tan^2 x}$$

Candidates should be able to select and use identities appropriate to context, for example when solving equations or rearranging expressions into a form that can be integrated.

Sequences and Series
Candidates should be familiar with the notation associated with sequences and series and the different ways in which sequences may be defined. When working with binomial expansions, they should also be clear about the use of terminology, being able to distinguish between term and coefficient and to understand what is meant by the term 'independent of x' (e.g. Specimen Paper 1, question 3). Solving problems involving geometric series provides a reason for introducing logarithms to solve equations of the form $a^n = b$. Similarly, it would be possible to link the study of geometric series and binomial expansions to the relevant distributions in the Probability section of the syllabus, in order to emphasise the way in which similar structures appear in apparently different branches of mathematics.

Logarithms and Exponentials
The relationship between In x and e^x as inverse functions has already been mentioned in the section on functions. Candidates should be aware of the laws of logarithms and how these may be used to simplify expressions. In particular:

$\log a + \log b = \log (ab)$

$\log a - \log b = \log \left(\frac{a}{b}\right)$
$-\log b = \log \left(\frac{1}{b}\right)$

$n\log a = \log (a^n)$
$\log 1 = 0$
$\log_a a = 1$

Candidates will also be expected to work with expressions presented in the form of indices and to understand how such expressions can be manipulated (e.g. Specimen Paper 1, question 5)

Differentiation

Given the linear nature of the Cambridge Pre-U Mathematics course, differentiation is treated as a single topic in the syllabus. However for the purposes of teaching it makes sense to break this topic down into sections that can be interspersed throughout the course. This has the benefit of introducing the concept relatively early in the course, whilst providing reinforcement by revisiting the topic at regular intervals. There is also scope to discuss differentiation alongside other methods that locate maximum and minimum values, for example completing the square for quadratics and use of the fact that sine and cosine vary between 1 and –1. Knowledge of differentiation from first principles is required.

It should be noted that parametric equations are not treated as a separate topic within the syllabus, but are included within the differentiation topic. In particular candidates need to be able to find both first and **second** derivatives of functions defined parametrically or implicitly.

Although many standard results are included in the formula book, candidates will be expected to recall the following derivatives:

Function	Derivative
x^n	nx^{n-1}
e^x	e^x
$\ln x$	$1/x$
$\sin x$	$\cos x$
$\cos x$	$-\sin x$

Candidates must also know the product and quotient rules:

Where a function can be expressed as a product uv, the derivative is $uv' + vu'$

Where a function can be expressed as a quotient $\frac{u}{v}$, the derivative is $\frac{vu' - uv'}{v^2}$

Integration

As with differentiation, Cambridge Pre-U Mathematics treats integration as a single topic in the syllabus. Again for the purposes of teaching it makes sense to break this topic down into sections that can be interspersed throughout the course. The calculus topics of integration and differentiation provide excellent scope for emphasising the interconnected nature of the mathematics. For example, attempting to integrate a quotient may generate the need for partial fractions thus providing a reason for introducing the new method, rather than as an abstract technique. It would also be possible to use Mechanics as a practical means of introducing calculus topics to candidates.

Although many standard results are given, candidates will be expected to recall the following integrals:

Function	Integral
x^n, for $n \neq -1$	$\frac{x^{n+1}}{n+1}$
x^{-1}	$\ln x$
e^x	e^x
$\sin x$	$-\cos x$
$\cos x$	$\sin x$

Vector Geometry

The study of vector geometry can be used to complement the coordinate geometry section, but also as a way of introducing methods that are of use in Mechanics. Candidates should understand that the scalar product of two vectors can be used to calculate the angle between two vectors and appreciate that when two non-zero vectors **a** and **b** are such that **a.b** = 0 then they are perpendicular. The relationship between the scalar product and the angle between vectors is not given in the formula book and must be recalled.

The angle θ between the vectors **a** and **b** is given by $\cos\theta = \dfrac{\mathbf{a}.\mathbf{b}}{|\mathbf{a}||\mathbf{b}|}$

Differential Equations

Candidates should be able to recognise equations that can be solved by separating variables. They should be able to set up differential equations from questions involving rates of change and may need to use the chain rule in order to obtain an equation in the form required for solving. Integrals will be consistent with the techniques covered in the integration section of the syllabus.

Complex Numbers

Although found in AS or A Level Further Mathematics, the basic idea of complex numbers can be dealt with at this level and provides an answer to the awkward question of what happens when the discriminant of a quadratic equation is negative. When calculating the magnitude and argument of complex numbers candidates should be aware of the similarity with the methods used in vector geometry.

Numerical Methods

Change of sign methods and iterative methods of the form $x_{n+1} = f(x_n)$ are found in A Level specifications, however in most cases the Newton-Raphson method is covered at Further Mathematics level. Candidates need to be able to use this method and to understand the graphical explanation for why this method works.

Paper 1 – Probability Content

Analysis of Data
Candidates need to be able to calculate and interpret measures of central tendency and measures of spread, interpreting the results in context. The formulae for Pearson's Product Moment Correlation Coefficient and for the coefficients of the least squares regression line are given, as are s_{xx}, s_{yy} and s_{xy}. Candidates will need to know how these relate to standard deviation and variance.

Probability Laws
Candidates will need to understand what is meant by independence and how this relates to questions involving conditional probability, for example Specimen Paper 1, question 12.

Permutations and Combinations
Questions relating to the arrangement of objects can appear in a wide range of contexts, many of which require careful enumeration of the different possible structures available, as seen in Specimen Paper 1, question 14.

Discrete Random Variables
The formulae for expectation and variance are given as are the formulae for the standard distributions covered in the syllabus. There is scope here to show links with the Binomial expansion and with geometric series in order to give candidates the opportunity to see how similar structures occur in different branches of mathematics. They will need to be able to identify the situations in which each model is appropriate. In particular, they will need to be able to apply the formulae relating to geometric series in order to solve problems, for example Specimen Paper 1, question 15.

Normal Distribution
Candidates will be expected to know how to use tables to look up probabilities associated with the Normal distribution correctly.

Paper 2 – Mechanics Content

Kinematics of Motion in a Straight Line
No formulae are given relating to this topic, so candidates will be expected to know the constant acceleration formulae:

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \frac{(u+v)t}{2}$$

They will also need to know the calculus relationships associated with displacement–time and velocity–time graphs. The equations presented in this context could potentially be drawn from the full range of functions covered in the differentiation and integration sections of the Pure Mathematics content.

Force and Equilibrium
Candidates will be expected to resolve forces as seen in Specimen Paper 2, question 11.

Friction
Candidates will need to be familiar with the standard terminology used in Mechanics, understanding what is meant by ‘smooth’, ‘rough’, ‘light’, ‘inextensible’, etc, as seen in Specimen Paper 2, question 12. Solutions to problems may well take the form of algebraic expressions, rather than numerical answers and as such there should be some appreciation of what may happen if one or more of the variables changes.

Newton’s Laws of Motion
The formula $F = ma$ is not given so must be learned.

Linear Momentum and Impulse
No formulae are given, but candidates should be familiar with both of the following forms for impulse:

Impulse = Ft and Impulse = $mv - mu$

They should also know Newton’s law of restitution:

$$e = \frac{v_{sep}}{v_{app}}$$

Motion of a Projectile
Specimen Paper 2, question 14 suggests that again algebraic solutions may be required. Candidates may need to make use of appropriate trigonometric identities and should understand how changes in variables relate to the practical problem.

Mapping the Cambridge Pre-U Further Mathematics Syllabus to A Level Content

Candidates studying Cambridge Pre-U Further Mathematics will need to be familiar with the content of Cambridge Pre-U Mathematics or A Level Mathematics. As there is some variation in the topics included in the various Further Mathematics A Level specifications, the following table is intended to assist teachers with mapping the course to existing resources.

Paper 1 – Further Pure Mathematics **Topic**	OCR	OCR (MEI)	AQA	EDEXCEL
Rational Functions	FP2	FP1	FP1	N/A
Roots of Polynomials	FP1	FP1	FP1, FP2	N/A
Complex Numbers	FP1	FP1	FP2	FP1
De Moivre's Theorem	FP3	FP2	FP2	FP3
Polar Coordinates	FP2	FP2	FP3	FP1
Summation of Series	FP1	FP1,FP2	FP1, FP2	FP1
Mathematical Induction	FP1	FP1	FP2	FP3
Calculus	FP2	FP2	FP2, FP3	FP2, FP3
Hyperbolic Functions	FP2	FP2	FP2	FP2
Differential Equations	FP3	DE	FP3	FP1
Vector Geometry	FP3	FP3	FP4	FP3
Matrices	FP1	FP1,FP2	FP1, FP4	FP3
Groups	FP3	FP3	N/A	N/A

Paper 2 – Further Applications of Mathematics **Topic**	OCR	OCR (MEI)	AQA	EDEXCEL
Mechanics				
Energy, Work and Power	M2	M2	M2	M2
Motion in a Circle	M2, M3	M3	M2	M3
Relative Motion	M4		M3	M4
Elastic Strings and Springs	M3	M3		M3
Simple Harmonic Motion	M3	M3	M5	M3
Further Particle Dynamics		M1/M2	M3	
Linear Motion under a Variable Force	M3	M4		M3
Probability				
Poisson Distribution	S2	S2	S2	S2
Normal Distribution as Approximation	S2	S2	S1	S2
Continuous Random Variables	S2,S3	S3	S2	S2
Linear Combinations of Random Variables	S3	S4	S3	S3
Estimation	S2	S4	S1, S3	S3
Probability Generating Functions	N/A	S4	N/A	N/A
Moment Generating Functions	S3	S4	N/A	N/A

Elaboration on the Content of the Cambridge Pre-U Further Mathematics Syllabus

It is expected that candidates will have a secure grounding in the basic principles of advanced mathematics consistent with the material covered in Cambridge Pre-U Mathematics or A Level Mathematics.

Paper 1 – Further Pure Mathematics

Rational Functions

When studying this topic, the use of graphic calculators or graph drawing software can aid understanding, however, it should be remembered that candidates will only have access to scientific calculators in the examination. Specimen Paper 1, question 8 is an example of a problem in which candidates are expected to identify an oblique asymptote.

Roots of Polynomials

No restriction is placed on the order of polynomials which may be included in this topic. Consequently candidates should be familiar with the relationships associated with quadratics and cubics and understand how to extend these ideas to polynomials of higher order. Specimen Paper 1, question 7 is an example of a problem involving a cubic equation and equations with related roots.

Complex Numbers and De Moivre's Theorem

For candidates who have studied A Level Mathematics, it will be necessary to introduce the basic concept of complex numbers before moving on to the material in these sections of the Further Mathematics syllabus. The general form for the n^{th} roots of unity is given in the formula book, as are the relationships

$$e^{i\theta} = \cos\theta + i\sin\theta \quad \text{and} \quad \{r(\cos\theta + i\sin\theta)\}^n = r^n(\cos n\theta + i\sin n\theta).$$

Polar Coordinates

Whilst graphic calculators and graph drawing software are useful tools in the teaching of this topic they are not available in the examination. In particular, candidates need to be aware of how the form of a polar equation determines the shape of the curve. Specimen Paper 1, question 6 gives an example where the symmetry of the curve needs to be explained in terms of the equation.

Summation of Series

Although the standard results for Σr^2 and Σr^3 are given in the formula book, candidates will need to know Σr.

Mathematical Induction

Specimen Paper 1, question 2 gives an example of a divisibility test using proof by induction. Candidates should be prepared to recognise when inductive proofs are appropriate in a wide range of situations.

Calculus
This section of the syllabus covers a number of techniques and for teaching purposes it may be convenient to deal with these separately. The Maclaurin series for a number of functions are given in the formula book, as are the standard integrals associated with the inverse trigonometric functions. Specimen Paper 1, question 13 highlights the need to be able to deduce results from the basic formula as well as from known results. Question 14 links the use of reduction formulae to the concepts of convergence covered in the Summation of Series section of the syllabus. The formulae for arc length and curved surface area are also provided.

Hyperbolic Functions
The logarithmic forms of the inverse hyperbolic functions are given in the formula book, as are the identities for sinh 2x and cosh 2x. Specimen Paper 1, question 3 gives an example of a problem which can be solved by substituting for the hyperbolic functions in terms of the exponential function.

Differential Equations
In this section a range of differential equations are considered and candidates will need to be able to identify appropriate strategies for the solution of problems. This topic also has relevance for Paper 2 since it is reasonable to expect that questions may be encountered where differential equations arise in a practical context.

Vector Geometry
This section builds on the work on vector geometry covered in the Mathematics syllabus. When considering the scalar triple product and its application to practical problems it will be useful to make reference to the matrices section of the syllabus.

Matrices
The geometrical interpretation of problems, particularly in 3 dimensions, will require knowledge of the vector geometry topic. Specimen Paper 1, question 10 deals with this topic.

Groups
Specimen Paper 1, question 11 illustrates the need to be able to work with an arbitrary binary operation. It should also be emphasised that whilst candidates need to be familiar with groups up to order 7, groups of higher order may also be encountered.

Paper 2 – Further Applications of Mathematics

Mechanics
Candidates should already be familiar with the Mechanics content of Cambridge Pre-U Mathematics. Many of the questions set within this section of the paper may involve algebraic solution, requiring the candidates to present a sustained mathematical argument.

Energy, Work and Power

The formulae for kinetic energy $\frac{1}{2}mv^2$ and gravitational potential energy mgh should be known, as should the formula for power, Fs.

Motion in a Circle
Formulae relating to circular motion are given in the formula book.

Relative Motion
Many candidates find this topic difficult to tackle and the use of suitable vector diagrams to assist with understanding is often helpful. The mark scheme for Specimen Paper 2, question 2 indicates how either a component or velocity diagram approach may be used to successfully solve such problems.

Elastic Strings and Springs
The formulae associated with elastic strings and springs should be known, in particular that force is $kx = \lambda \frac{x}{l_o}$ and elastic potential energy is $\frac{1}{2} kx^2 = \frac{1}{2} \lambda \frac{x^2}{l_o}$, where x is the extension, k is the stiffness of the string or spring and λ is the modulus of elasticity.

Simple Harmonic Motion
Candidates will need to be able to recognise the simple harmonic motion equation $\ddot{x} = -\omega^2 x$ and know how to deal with cases that can be reduced to this form by appropriate substitutions. They should also be familiar with the terminology associated with simple harmonic motion, such as amplitude and period ($T = \frac{2\pi}{\omega}$) and use standard solutions such as $x = a\sin(\omega t + \varepsilon)$ and related results (e.g. $v^2 = \omega^2(a^2 - x^2)$). Specimen Paper 2, question 3 gives an example of how standard results may be applied to a problem involving simple harmonic motion.

Further Particle Dynamics
This section deals with more sophisticated impulse, momentum and projectile problems than those encountered in the Cambridge Pre-U Mathematics paper.

Linear Motion under a Variable Force
Specimen Paper 2, question 4 gives an example of how this topic can link the use of differential equation techniques with the principles of mechanics.

Probability
Candidates should already be familiar with the Probability content of Cambridge Pre-U Mathematics. Those who have studied A Level Mathematics may need to undertake preparatory work relating to the Binomial and Normal distributions depending on the combination of applied units they have studied.

Poisson Distribution
The formula for the Poisson distribution is given in the formula book and cumulative probability tables are also provided. Candidates should appreciate the conditions for which it is appropriate to use the Poisson distribution and also when it is appropriate to be used as an approximating distribution for the Binomial distribution. Specimen Paper 2, question 10 relates to this topic.

Normal Distribution as Approximation
The Normal distribution was introduced in Cambridge Pre-U Mathematics. At this level its use as an approximating distribution for both the Binomial and Poisson distributions is considered. As they are both discrete distributions candidates will need to understand how to apply continuity corrections and the conditions under which approximation is appropriate. Specimen Paper 2, question 8 illustrates how this topic may appear.

Continuous Random Variables
In this topic candidates will see how calculus methods can be applied in a probability context. An example of this type of question can be found in Specimen Paper 2, question 7.

Linear Combinations of Random Variables
Understanding how to combine random variables is central to more advanced probability theory. Specimen Paper 2, question 12 gives an example of how this may be applied.

Estimation
This topic enables candidates to appreciate the relationship between samples and populations, in particular understanding how samples can be considered in terms of random variables. The formula book includes information about unbiased estimators for mean and variance.

Probability and Moment Generating Functions
The probability generating functions for the Binomial, Geometric and Poisson distributions are given in the formula book. Specimen Paper 2, question 11 gives an example of how this information may be applied. The moment generating functions for the Uniform (Rectangular), Exponential and Normal distributions are given in the formula book. Candidates will need to know how to derive and interpret these functions.

Suggested Schemes of Work for Mathematics and Further Mathematics

It is intended that the Cambridge Pre-U Mathematics course will require 380 guided learning hours, which includes both teacher contact and other structured learning time such as directed assignments or supported individual study and practice. Depending on timetable allocations within institutions, it is likely that the ratio of contact time to other study will be in the region of 70 percent to 30 percent. Given that the Cambridge Pre-U is a linear course with assessment at the end of the second year of study, the division of time across the two years of the course is likely to be weighted towards the first year in order to make full use of all three terms, with a possible split of 210 to 170.

When considering the order in which to teach topics, it would be possible to follow a pattern similar to the modular A Level specifications, which would enable Centres to make use of their existing C1/C2 and C3/C4 textbooks. As the applications are part of the terminal assessment, Centres might also prefer to teach both of these in the second year of the course together with some of the more synoptic topics such as differential equations and some of the more advanced calculus techniques. Some Centres may prefer to develop their own schemes of work making use of logical connections between topics.

Similarly, it is intended that the Cambridge Pre-U Further Mathematics course will require 380 guided learning hours which includes both teacher contact and other structured learning time such as directed assignments or supported individual study and practice. The content of the Further Mathematics syllabus builds on the material covered in the Cambridge Pre-U Mathematics, but would also be accessible to candidates who had studied A Level Mathematics.

There are a number of models possible for the delivery of the Further Mathematics course. Some Centres may choose to complete all the material for the Pre-U Mathematics course in year 12 before starting the Further Mathematics material in year 13. It should be noted that the first year for examination of the Pre-U qualifications is 2010, so for candidates starting the course in 2008 it will be necessary to take both Mathematics and Further Mathematics examinations at the end of year 13, but for candidates starting in 2009, or later, the option will be available for them to take the Mathematics examination after the first year of study and the Further Mathematics examination at the end of the second year.

Alternatively, some Centres may choose to deliver the Mathematics and Further Mathematics courses in parallel over two years. Such an approach would require careful scheduling of topics to ensure that candidates have the pre-requisite knowledge for the Further Mathematics material.

Activities for Independent Study

In addition to practising the many techniques involved in Mathematics at this level, it is hoped that candidates will develop an understanding of the role of mathematics in a wide range of contexts, not only in what may be regarded as perhaps the traditional areas of science and technology, but in other areas including geography, economics and social sciences. Candidates should be encouraged to read around the subject, taking particular note of mathematical applications that may relate to their other areas of study. For candidates following the Cambridge Pre-U core of Global Perspectives and the Independent Research report, there is scope to investigate areas of mathematical interest, perhaps by researching the work of particular mathematicians, or the use of mathematics in current society. There would also be scope for devising a particular experiment or investigation that makes direct use of the candidates' mathematical knowledge.

Cambridge Pre-U Online Communities

If you wish to find out more about issues relating to the on-going development of Cambridge Pre-U courses and related teaching materials, this can be found on the Cambridge Pre-U online community website. This is a discussion based website that has been established to support teachers. The discussion forums enable teachers to discuss issues of common interest relating to the Cambridge Pre-U courses and to download and share resources that are being developed to support the courses. Material on the discussion forums will also complement INSET for the delivery of the Cambridge Pre-U. If you wish to make use of this opportunity to share ideas with other teachers and access the resources, you will need to register on the site.

Suggested Resources

Most of the topics in the Pure Mathematics section of the Cambridge Pre-U Mathematics course can be found in existing AS (C1/C2) and A Level (C3/C4) textbooks. However, in most cases this material will need to be supplemented to include work on complex numbers and the Newton-Raphson method for the numerical solution of equations. In the applications sections the overlap with existing modular textbooks is less straightforward, but sufficient coverage should be found by using material from M1, M2, S1 and S2 books depending on the syllabus previously followed by schools (see Mapping the Cambridge Pre-U Mathematics Syllabus to A Level Content section). In addition to textbooks designed for modular specifications, Centres may also find books designed for linear courses helpful. Many departments will have copies of pre-modular textbooks on their shelves and a number can still be obtained from publishers. You may find some of the following titles useful:

Pure Mathematics

Bostock, L. & Chandler, F. S. *Core Maths for Advanced Level,* Nelson Thornes
Bostock, L., Chandler, F. S. & Rourke, C. P. *Further Pure Mathematics,* Nelson Thornes
Gaulter, M. & Gaulter, B. *Further Pure Mathematics,* OUP
Sadler, A. J. & Thorning, D.W.S. *Understanding Pure Mathematics,* OUP

Mechanics

Sadler, A. J. & Thorning, D.W.S. *Understanding Mechanics*, OUP

Statistics

Crawshaw, J. & Chambers, J. *A Concise Course in A Level Statistics,* Nelson Thornes

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