Higher
Course
Specification

Higher Applications of Mathematics Course Specification

Course code:	C844 76
Course assessment code:	X844 76
SCQF:	level 6 (24 SCQF credit points)
Valid from:	session 2021–22

This document provides detailed information about the course and course assessment to ensure consistent and transparent assessment year on year. It describes the structure of the course and the course assessment in terms of the skills, knowledge and understanding that are assessed.

This document is for teachers and lecturers and contains all the mandatory information required to deliver the course.

This edition: June 2020 (version 1.0)

Contents

Course overview

This course consists of 24 SCQF credit points, which includes time for preparation for course assessment. The notional length of time for candidates to complete the course is 160 hours.

The course assessment has two components.

Component	Marks	Duration
Component 1: question paper	80	2 hours and 30 minutes
Component 2: project	30	8 hours

Recommended entry	Progression
Entry to this course is at the discretion of the centre. Candidates should have achieved the National 5 Mathematics course or the National 5 Applications of Mathematics course or equivalent qualifications and/or experience prior to starting this course.	♦ other qualifications in mathematics or related areas, for example Advanced Higher Statistics ♦ further study, employment and/or training

Conditions of award

The grade awarded is based on the total marks achieved across both course assessment components.

Achievement of this course gives automatic certification of the following Core Skill:

♦ Numeracy at SCQF level 6

Course rationale

National Courses reflect Curriculum for Excellence values, purposes and principles. They offer flexibility, provide time for learning, focus on skills and applying learning, and provide scope for personalisation and choice.

Every course provides opportunities for candidates to develop breadth, challenge and application. The focus and balance of assessment is tailored to each subject area.

The Higher Applications of Mathematics course focuses on developing the mathematical and analytical skills required in society and for the future workforce. The course develops candidates' quantitative and mathematical literacy, problem-solving skills and reasoning skills as they apply mathematics in real-life contexts.

Applying mathematics in real-life contexts includes identifying relevant information, formulating a problem in appropriate mathematical or statistical terms, selecting and applying tools correctly, finding solutions, interpreting solutions in the context of a problem, and evaluating the approach taken.

The skills, knowledge and understanding in the course supports learning and further study and builds confidence in a wide range of curricular areas, such as humanities, social sciences, healthcare, and business.

Purpose and aims

The course enhances candidates' critical and logical thinking so that they can interpret, analyse, and critically appraise statistical and mathematical information; simplify and solve problems; assess risk; and make informed decisions.

The course aims to:

- equip candidates with the mathematical and statistical literacy skills they need for life, work and further study in a wide range of curricular areas
- develop candidates' financial literacy in real-life contexts
- show candidates how they can use appropriate digital technology to manipulate and model mathematical, statistical and financial information
- develop candidates' mathematical reasoning skills so that they can generalise, build arguments, draw logical conclusions, assess risk, and make informed decisions in familiar and unfamiliar situations
- develop candidates' range of mathematical skills so that they can analyse, interpret and present data and numerical information
- provide candidates with the skills to appraise quantitative information critically, considering modelling or statistical assumptions

Who is this course for?

This course is suitable for candidates:

- who have completed the National 5 Applications of Mathematics course or the National 5 Mathematics course
- returning to education
- interested in developing the mathematical reasoning and numerical skills that are useful in other curriculum areas and workplaces

Course content

The Higher Applications of Mathematics course develops, deepens and extends the operational and reasoning skills necessary for solving problems. Through real-life contexts, candidates acquire and apply mathematical and statistical skills directly relevant to life and work, and learn about how mathematics affects the world they live in.

Candidates analyse complex real-life problems and gain experience in making and justifying decisions and drawing conclusions.

Skills, knowledge and understanding

Skills, knowledge and understanding for the course

The following provides a broad overview of the subject skills, knowledge and understanding developed in the course:

- analyse complex real-life situations and problems involving mathematics
- select and apply skills in finance, statistics and probability, data modelling, and planning and decision making
- communicate mathematical information with complex features
- select and apply skills in numeracy
- use mathematical reasoning skills to extract and interpret information and draw conclusions or justify decisions
- use software where appropriate, for example to model and analyse statistical, mathematical, and financial problems

Skills, knowledge and understanding for the course assessment

The following provides details of skills, knowledge and understanding sampled in the course assessment.

Mathematical modelling	
Skills	**Explanation**
Understanding and applying the process of mathematical modelling to evaluate, analyse and interpret mathematical models	♦ modelling a situation mathematically in a given context using: — appropriate variables — an appropriate form — formulae — graphs and charts ♦ defining appropriate units of measure for variables and checking for consistency ♦ evaluating the effects of error and tolerances within mathematical models: — calculating the limits for compound measures, for example velocity, density, or journey times — determining if a process is within tolerance ♦ evaluating and interpreting the output of mathematical models ♦ analysing mathematical models and suggesting possible improvements
Using software effectively in calculations	♦ using software to carry out calculations in a way that another independent user can easily understand and check, including: — incorporating clear and consistent presentation — setting up key variables before using them in calculations ♦ understanding and applying the following knowledge: — editing and sorting data — creating and labelling charts and graphs — using standard functions to generate formulae — producing output

Statistics and probability	
Skills	**Explanation**
Applying statistical skills to basic probability	♦ constructing tree diagrams and Venn diagrams ♦ carrying out basic calculations involving the combination of events, where information may be displayed in tables or graphs, such as tree diagrams and Venn diagrams
Applying statistical literacy skills to data	♦ understanding the following: — types of data — populations and samples — outliers — gathering data and associated issues ♦ constructing and interpreting statistical diagrams, for example: — frequency tables — stem-and-leaf diagrams — pie charts — bar charts — box plots — contingency tables — histograms — misleading graphs ♦ interpreting the distribution of data, with particular reference to symmetry, normality, and skewness ♦ deriving, understanding, and interpreting sample measures of location and dispersion, including mean and standard deviation, and median and interquartile range
Applying statistical skills to correlation and linear regression	♦ interpreting and constructing scatter plots ♦ using simple linear regression ♦ interpreting the slope and intercept parameters in relation to data ♦ using linear models for prediction ♦ assessing the accuracy of predictions ♦ understanding and interpreting correlations ♦ understanding the applicability of Pearson's product-moment correlation coefficient ♦ exploring trends in data, for example seasonality
Applying statistical skills to data analysis, interpretation and communication	♦ formulating research questions ♦ interpreting and reporting the results of a hypothesis test ♦ generating, understanding, and interpreting confidence intervals ♦ performing simple analysis using t-tests and paired t-tests

Statistics and probability	
Skills	**Explanation**
	♦ using z-tests for two proportions ♦ understanding how errors can arise in statistical testing, including confounding variables ♦ interpreting and relating results of a hypothesis test to the original research question

Finance	
Skills	**Explanation**
Applying mathematical skills to calculating present and future values of monetary payments	♦ understanding the concept of capital and interest and performing calculations involving effective rates of interest, including: — interest rates that are fixed or vary over time — expressing interest rates in different time frequencies ♦ calculating the present value and accumulated value of a single payment and a series of payments under the following scenarios: — regular, level payments — irregular and ad hoc payments — regular payments that increase or decrease by a fixed amount or fixed proportion each time period — payments that are deferred for some period of time — an effective rate of interest that is fixed or varies over time, including at a different frequency to that of the payments
Applying mathematical skills to solving problems related to personal financial products and transactions and analysing the results	**Credit cards and loans** ♦ understanding the purpose of credit cards and loans ♦ solving and analysing problems relating to credit cards and loans, including: — the effective rate of interest for a loan or credit card — constructing a schedule of repayments for a loan or credit card — calculating revised figures as a result of alterations, for example to loan terms, interest rates, and overpayment ♦ analysing the risks associated with credit cards and loans

Finance	
Skills	**Explanation**
	Savings products ♦ understanding the purpose of savings products ♦ solving and analysing problems relating to savings products, including saving for a specific goal (for example regular or irregular pension contributions saving towards retirement) or an unspecified goal (for example general savings for no specific purpose) ♦ analysing the risks associated with savings products **Insurance** ♦ understanding the purpose of insurance products ♦ analysing the risks associated with insurance products
Applying personal financial planning skills	♦ understanding the following monetary concepts, applying these in financial calculations, and interpreting their impacts: — taxation systems — inflation and purchasing power of money; comparing alternative strategies that individuals could take in relation to their financial planning (for example borrowing money) ♦ analysing and interpreting the risks associated with financial planning strategies

Planning and decision making	
Skills	**Explanation**
Understanding and applying project planning and decision making	♦ representing compound projects by activity networks using activity-on-node representation, for example Programme Evaluation and Review Technique (PERT) charts ♦ using systematic methods to find early and late times for activities, and then identifying critical activities and finding critical paths ♦ using Gantt charts to represent project activities ♦ understanding and interpreting risk by calculating the expected value of costs and benefits of decisions ♦ applying expected value to real-life contexts and understanding this is an important part of decision making

Skills, knowledge and understanding included in the course are appropriate to the SCQF level of the course. The SCQF level descriptors give further information on characteristics and expected performance at each SCQF level, and are available on the SCQF website.

Skills for learning, skills for life and skills for work

This course helps candidates to develop broad, generic skills. These skills are based on SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for Work and draw from the following main skills areas:

1 Literacy
1.2 Writing

2 Numeracy
2.1 Number processes
2.2 Money, time and measurement
2.3 Information handling

4 Employability, enterprise and citizenship
4.2 Information and communications technology (ICT)

5 Thinking skills
5.3 Applying
5.4 Analysing and evaluating

You must build these skills into the course at an appropriate level, where there are suitable opportunities.

Course assessment

Course assessment is based on the information in this course specification.

The course assessment meets the purposes and aims of the course by addressing:

- breadth — drawing on knowledge and skills from across the course
- challenge — requiring greater depth or extension of knowledge and/or skills
- application — requiring application of knowledge and/or skills in practical or theoretical contexts as appropriate

This enables candidates to:

- develop mathematical and statistical operational skills
- analyse and interpret real-life situations and problems involving mathematics and statistics in new and unfamiliar situations
- combine mathematical and statistical operational skills from across the course to tackle real-life situations or problems
- apply digital technology to process a range of mathematical and statistical skills
- use mathematical and statistical reasoning skills to draw conclusions or justify decisions
- communicate mathematical and statistical information appropriately

Course assessment structure: question paper

Question paper 80 marks

The question paper allows candidates to demonstrate the application of mathematical skills, knowledge and understanding from across the course.

The question paper gives candidates an opportunity to apply an understanding of the underlying processes involved in mathematical modelling, statistics, finance, planning and decision making, numerical skills, and reasoning skills as specified in the 'Skills, knowledge and understanding for the course assessment' section.

The question paper has 80 marks out of a total of 110 marks for the course assessment.

Setting, conducting and marking the question paper

SQA sets and marks the question paper. It is conducted in centres under conditions specified for external examinations by SQA.

Candidates have 2 hours and 30 minutes to complete the question paper.

Specimen question papers for Higher courses are published on SQA's website. These illustrate the standard, structure and requirements of the question papers. The specimen papers also include marking instructions.

Resources

The question paper requires candidates to use spreadsheet and statistical software. They must have access to the following resources:

- a computer, without internet access
- electronic files supplied by SQA
- spreadsheet software and statistical software

Course assessment structure: project

Project 30 marks

The project gives candidates an opportunity to demonstrate the following statistical skills, knowledge and understanding:

- applying statistical skills to data
- analysing data, interpreting and communicating findings using statistical skills

The project has 30 marks out of a total of 110 marks for the course assessment.

Candidates research and report on a topic that allows them to apply statistical skills and knowledge in Applications of Mathematics at a level appropriate to Higher.

Setting, conducting and marking the project

Setting

The project is set:

- at a time appropriate to the candidate's needs
- within learning and teaching, at a level appropriate to Higher

Conducting

The project is:

- an individually produced piece of work from each candidate
- started at an appropriate point in the course

Marking

The project is submitted to SQA for external marking. SQA quality assures all marking.

Assessment conditions

Time

Candidates must complete the project:

- in approximately 8 hours
- in time to meet the submission date set by SQA

Supervision, control and authentication

Candidates complete the project under some supervision and control, which means that they do not need to be directly supervised at all times.

Resources

The project requires candidates to use statistical software (for example RStudio and Minitab). They must, therefore, have access to digital technology, such as a computer or tablet, and statistical software.

Reasonable assistance

The term 'reasonable assistance' is used to try to balance the need for support with the need to avoid giving too much assistance, for example, drawing out points without leading candidates. Candidates must undertake the project independently. Candidates sometimes get stuck at a particular part of a task. In such cases, you could assist by raising other questions that make the candidate think about the original problem, therefore giving them the opportunity to answer their own questions without supplying the answers.

You must be careful that the integrity of the assessment is not compromised. You must not provide model answers.

Evidence to be gathered

The following candidate evidence is required for submission to SQA:

- an electronic or handwritten report incorporating output from statistical software, for example tables of descriptive statistics, appropriate graphs, or charts
- analysis and summary of their research question

Volume

The project report should not exceed 2000 words, excluding the title page, contents page, tables of data, graphs, diagrams, calculations, references, acknowledgements, and any appendices.

Candidates must include their word count on the project report flyleaf.

If the word count exceeds the maximum by more than 10%, a penalty is applied.

Grading

Candidates' overall grades are determined by their performance across the course assessment. The course assessment is graded A–D on the basis of the total mark for both course assessment components.

Grade description for C

For the award of grade C, candidates will typically have demonstrated successful performance in relation to the skills, knowledge and understanding for the course.

Grade description for A

For the award of grade A, candidates will typically have demonstrated a consistently high level of performance in relation to the skills, knowledge and understanding for the course.

Equality and inclusion

This course is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

Guidance on assessment arrangements for disabled candidates and/or those with additional support needs is available on the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Further information

The following links provide useful information and background:

- Higher Applications of Mathematics subject page
- Assessment arrangements web page
- Building the Curriculum 3–5
- Guide to Assessment
- Guidance on conditions of assessment for coursework
- SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work
- Coursework Authenticity: A Guide for Teachers and Lecturers
- Educational Research Reports
- SQA Guidelines on e-assessment for Schools
- SQA e-assessment web page
- SCQF website: framework, level descriptors and SCQF Handbook

Appendix 1: course support notes

Introduction

These support notes are not mandatory. They provide advice and guidance to teachers and lecturers on approaches to delivering the course. Please read these course support notes in conjunction with the course specification and the specimen question paper and coursework.

Approaches to learning and teaching

The skills-based focus of the course lends itself to a variety of learning and teaching approaches, such as:

- learning for sustainability
- interdisciplinary learning
- cross-curricular opportunities
- investigative and problem-solving approaches
- collaborative working
- e-learning

Examples of how you can use each of these approaches within learning and teaching are described below.

Learning for sustainability

Learning for sustainability allows candidates to gain the knowledge, skills, attitudes, and values necessary to shape a sustainable future.

Candidates could:

- collect, record and interpret data on topics, such as climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption
- analyse the financial impact of consumerism and global trade
- investigate the environmental impact of oil tanker spills or crashes, pipeline failures, oilfield accidents, problems at refineries, and wars to find trends and present them graphically using spreadsheets

Interdisciplinary learning

Interdisciplinary learning can develop candidates' mathematical skills through scheduled or special events throughout the academic year.

Candidates could:

- design and build a school or college vegetable garden, using activity networks to plan the construction

- plan a school or college sports day, using activity networks to show which activities can take place simultaneously

Cross-curricular opportunities

Cross-curricular topics or themes can build on the relationship between mathematics and other subjects or curriculum areas.

Candidates could:

- use data on the Arctic Sea ice extent (total area) to predict the trend in area for the next several years to link with a geography topic
- use t-tests to determine if there is a statistically significant difference in the number of watts of power produced by different solar panels to link with a physics topic
- explore how practical tasks can be managed and organised using a Gantt chart to link with a technologies topic

Investigative and problem-solving approaches

Investigative and problem-solving approaches can provide opportunities for candidates to observe, explore, experiment, and discuss mathematical solutions to real-life problems.

Candidates could investigate data on the populations of the 5 continents over the last 50 years. They could spot trends, predict continental populations by 2050, and consider reasons for any differences between countries. They could use spreadsheets to simulate world population growth based on the present average birth rate and investigate what would happen if the average birth rate changed.

Prompt questions can determine candidates' understanding, for example: 'What did you do to work that out?', 'How much difference to world population growth would result if each mother had on average one child fewer, or one child more?'.

Collaborative working

Collaborative approaches can simulate real-life situations, encourage candidates to share tasks and promote team-working skills.

Candidates could, for example, independently compare and contrast fuel costs for hybrid electric and petrol-only powered vehicles. They could then work in groups to use descriptive statistics to analyse the cost of petrol throughout the UK, and investigate whether it makes financial sense to buy the more expensive hybrid version of a vehicle.

E-learning

ICT can support learning and teaching in this course. Candidates could use:

- ICT and other technologies, such as calculators and computers, for handling data and performing more complex calculations

- online tests and interactive programs
- spreadsheets and other data-handling programs, such as RStudio, to collect, record and manipulate data
- web-based resources, such as financial or health-related statistics, as stimulus material

Useful websites

The following table lists organisations that may provide resources suitable for this course.

Website	Possible resources or support materials
Gapminder	Gapminder produces free teaching resources including interactive graphs and charts, handouts and lesson plans, interactive presentations, and data sets linked to many aspects of global development.
The World Bank	The World Bank's Data Catalog is designed to make their development data easy to find, download, use, and share. It includes data from The World Bank's microdata, finances and energy data platforms, as well as datasets from the open data catalog.
Mathematics Education Innovation (MEI)	MEI's Critical Maths resources have been trialled in schools and are freely available. They are designed to enable students to think about real problems using mathematics. Topics covered include finance, statistics, probability, and decision making.
STEM Learning	STEM Learning's Core Maths resources are problem-solving focused and reinforce topics in meaningful contexts. The resources include lesson plans, presentations and student sheets. Topics include financial mathematics, statistics, probability, Gantt charts and activity networks.
University of Plymouth	The University of Plymouth's Core Maths Subject Support resources cover mathematical modelling, finance, critical path analysis, probability, and statistics.
An Introduction to SQA Statistics Higher Unit	This website is designed to accompany the SQA Statistics Award at SCQF level 6 (Higher level). There is a step-by-step guide to using RStudio to analyse and interpret data sets. There are PDF tutorials covering the content of the Statistics Award, along with additional resources to support statistics teaching.

Website	Possible resources or support materials
Quibans (Questions Inspired by a News Story)	The Quibans blog showcases relevant news stories along with mathematical questions and discussion points.
NRICH Maths	NRICH's Core Maths curriculum pages provide a rich variety of resources linked to problem solving, finance, graphs, statistics, and other areas.
Mathematics Assessment Resource Service (MARS)	MARS's website contains detailed lesson plans, and student activities. Topics include mathematical modelling, statistics, and probability.

The above resources were accurate at the time of publication and may be subject to change.

Preparing for course assessment

The course assessment focuses on breadth, challenge and application. Candidates draw on and extend the skills they have learned during the course. These are assessed through a question paper and project. The question paper and project will make use of software, for example spreadsheets and RStudio.

To help candidates prepare for the course assessment, they should have the opportunity to:

- analyse and interpret real-life situations and problems involving mathematics and statistics in new and previously unseen situations
- select and integrate mathematical and statistical operational skills from across the course to tackle real-life situations or problems
- apply a range of mathematical and statistical operational skills to an appropriate degree of accuracy
- use mathematical and statistical reasoning skills to draw conclusions or justify decisions
- communicate mathematical and statistical information appropriately

The question paper assesses a sample of the knowledge and skills acquired in the course and provides opportunities for candidates to apply skills in a wide range of situations, some of which may be unfamiliar.

The project assesses candidates' ability to use statistical skills to analyse and interpret data, and to communicate their findings.

Before the course assessment, candidates may benefit from:

- identifying particular aspects of work that need reinforcement and support
- responding to short-answer questions, multiple-choice questions and extended multi-step case study questions to prepare for the question paper
- using investigative techniques and statistical skills to prepare for the project

Developing skills for learning, skills for life and skills for work

You should identify opportunities throughout the course for candidates to develop skills for learning, skills for life and skills for work.

Candidates should be aware of the skills they are developing and you can provide advice on opportunities to practise and improve them.

SQA does not formally assess skills for learning, skills for life and skills for work.

There may also be opportunities to develop additional skills depending on the approach centres use to deliver the course. This is for individual teachers and lecturers to manage.

Some examples of potential opportunities to practise or improve these skills are provided in the following table.

SQA skills for learning, skills for life and skills for work framework definition	**Suggested approaches for learning and teaching**
Writing means the ability to create texts that communicate ideas, opinions and information, to meet a purpose and within a context.	Candidates could communicate applied knowledge and understanding throughout the course by interpreting quantitative information and making informed decisions, with an emphasis on applications of mathematics and statistics, and environmental, ethical, and social impacts.
Numeracy is the ability to use numbers to solve problems by counting, doing calculations, measuring, and understanding graphs and charts. This is also the ability to understand the results.	Candidates could make informed decisions based on the results of calculations; extracting information from graphs; interpreting written information and data in tables, charts and graphs; and interpreting information and data from the internet. This can extend their numerical skills.
Information and communications technology (ICT) involves having the ability to use ICT systems and emerging technologies to handle information. It means having the ability to use the internet safely and to make informed decisions based on information obtained using technology.	Candidates interact with technology during the course. This could provide opportunities to extend their ICT skills.

SQA skills for learning, skills for life and skills for work framework definition	Suggested approaches for learning and teaching
Applying is the ability to use existing information to solve a problem in a different context, and to plan, organise and complete a task.	Candidates could: ♦ apply the skills, knowledge and understanding they have developed to solve mathematical problems in a range of real-life contexts ♦ think creatively to adapt mathematical strategies to suit the problem or situation ♦ show and explain their thinking to determine their level of understanding ♦ think about how they are going to tackle problems, decide which skills to use and then carry out calculations to complete a task
Analysing and evaluating is the ability to identify and weigh-up the features of a situation or issue and to use your judgement of them in coming to a conclusion. It includes reviewing and considering any potential solutions.	Candidates could identify which real-life tasks or situations require the use of mathematics. They could interpret the results of their calculations and draw conclusions. The conclusions could be used as the basis for making and justifying choices or decisions to solve a given problem. Situations involving probability can provide appropriate contexts to develop analysis and evaluation skills.

During the course there are opportunities for candidates to develop their literacy skills and employability skills.

Literacy skills are particularly important as these skills allow candidates to access, engage in and understand their learning, and to communicate their thoughts, ideas and opinions. This course provides candidates with the opportunity to develop their literacy skills by analysing real-life contexts and communicating their thinking by presenting mathematical information in a variety of ways. This could include using numbers, formulae, diagrams, graphs, symbols and words.

Employability skills are the personal qualities, skills, knowledge, understanding, and attitudes required in changing economic environments. Candidates can apply the mathematical operational and reasoning skills developed in this course in the workplace. The course provides them with the opportunity to analyse a situation, decide which mathematical strategies to apply, work through those strategies effectively, and make informed decisions based on the results.

Appendix 2: skills, knowledge and understanding with suggested learning and teaching contexts

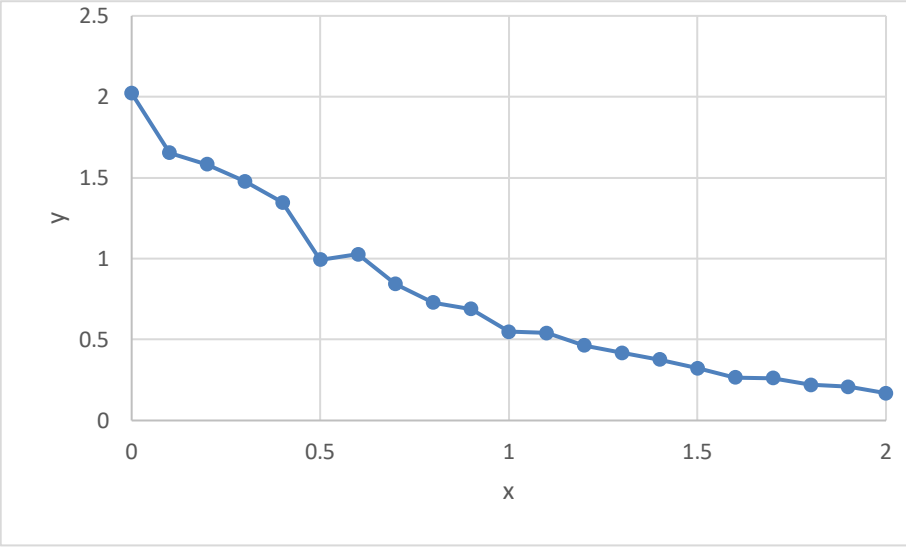
The first two columns are identical to the tables of 'Skills, knowledge and understanding for the course assessment' in the course specification.

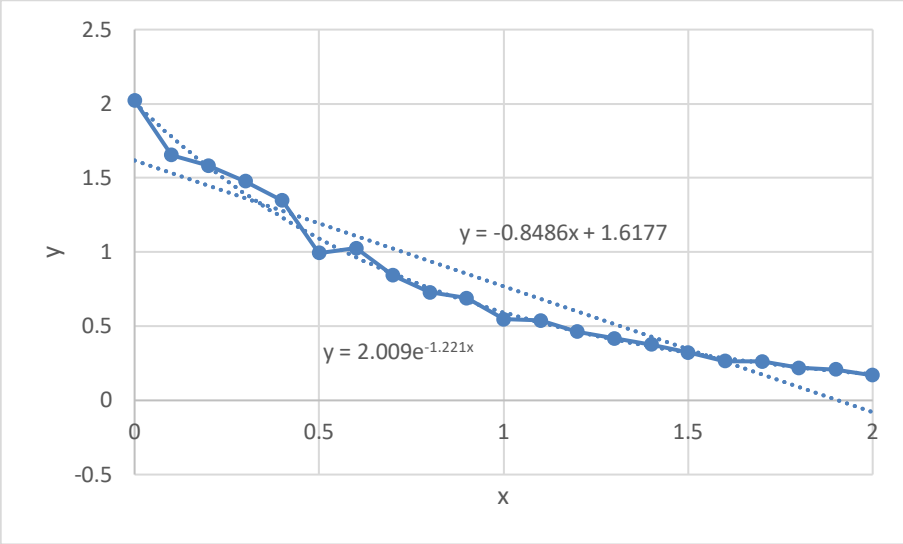
The third column gives examples of where the skills could be used in individual activities or pieces of work.

Mathematical modelling		
Skills	**Explanation**	**Examples**
Understanding and applying the process of mathematical modelling to evaluate, analyse and interpret mathematical models	♦ modelling a situation mathematically in a given context using: — appropriate variables — an appropriate form — formulae — graphs and charts	♦ given a situation described in words, identify the variables. For example: — when filling a bath that starts with some water in it, suitable variables could be the amount of water in the bath and time — when rats arrive for the first time on an island with plenty of food, suitable variables could be the rat population and time — a bridge over a river has zero height at either end but is higher in the middle, so suitable variables could be the height of the bridge and the position (distance across the river) ♦ recognise the shape and behaviour of linear, quadratic or exponential graphs: — linear relationship — increases or decreases at a constant rate — quadratic relationship — increases then decreases, or decreases then increases — exponential relationship — grows faster and faster or decays slower and slower Note: ideas from calculus, such as derivatives, are not required.

Mathematical modelling		
Skills	**Explanation**	**Examples**
		♦ given a situation described in words, suggest an appropriate mathematical model, such as a linear, quadratic, exponential or recurrence relationship between variables. For example: — when filling a bath that starts with some water in it, the amount of water in the bath and the time might be linearly related (until the bath is full) — when rats arrive for the first time on an island with plenty of food, the rat population might grow exponentially over time (until the food starts to run out) — a bridge over a river has zero height at either end but is higher in the middle, so the height of the bridge might be quadratically related to the distance across the bridge — the balance in a savings account at the end of one month is given by the amount at the end of the previous month multiplied by a suitable factor plus the net amount deposited over the month, which is a recurrence relation ♦ given a formula (linear, quadratic or exponential) relating two variables: — evaluate the formula to give the dependent variable for a given value of the independent variable — comment on whether the dependent variable is increasing or decreasing as the independent variable increases. For example, given the formula $N = 0 \cdot 1e^{-2t}$, identify that N decreases as t increases, and use a calculator or spreadsheet to evaluate N when $t = 3$

Mathematical modelling		
Skills	**Explanation**	**Examples**
		♦ given a graph or chart showing the relationship between two variables: — use the graph to estimate the value of one variable given the value of the other. For example, given a scatter plot, use a spreadsheet function to fit a straight line or an exponential function to the points, and use this to estimate intermediate values of the dependent variable — comment on whether the dependent variable is increasing or decreasing as the independent variable increases, and comment qualitatively on how fast it is changing at different points — identify key features of linear or exponential graphs. For example: ○ for a linear graph, know that the rate of change (the steepness of the graph) is constant, and determine it by taking differences ○ for an exponential graph, identify whether it shows growth or decay, and know that exponential growth gets progressively faster and exponential decay gets progressively slower ♦ given a graph or chart showing the relationship between two variables, and two possible formulae describing the relationship, discuss which formula is better

Mathematical modelling		
Skills	**Explanation**	**Examples**
		 Possible formulae: $y = 2e^{-1{\cdot}2x}$ or $y = 1{\cdot}6 - 0{\cdot}85x$. Questions that might inform the choice: — Is y decreasing steadily, or is it slowing down? — Do we need to worry about the bit where it seems to 'overshoot' and then go back up again? — Do we know anything else about the problem? For example, if this showed the decay of a drug in the bloodstream as a function of time x, the drug concentration y would be expected to approach zero and could not become negative; this is a strong hint that an exponential model would be appropriate. On the other hand, if it showed average daily temperature over successive weeks, then

Mathematical modelling		
Skills	**Explanation**	**Examples**
		there's no reason for it to flatten out. A linear model might be better, or even a quadratic model, if we expect the temperature to rise again. The 'best fit' linear and exponential fits to these data (as given by Excel) are shown below.  In fact, the graph was generated by taking $y = 2e^{-1.2x}$ and adding some random noise to it (with a range of plus or minus 10% at each point).

Mathematical modelling		
Skills	**Explanation**	**Examples**
	♦ defining appropriate units of measure for variables and checking for consistency	♦ identify suitable units of measure for a variable based on a formula or a verbal description of how it relates to other quantities. For example: — deduce from the formula $T = \frac{2\pi r}{v}$, where r is measured in metres and v is measured in metres per second, that T is measured in seconds — deduce from the statement, 'The price of a kilogram of gold is £40' that the price of gold can be measured in £ per kg ♦ determine whether the units of measure used in a comparison are inconsistent and, if they are inconsistent, deduce that the comparison is invalid. For example: — explain why the statement 'the perimeter of this shape is greater than its area' is wrong — explain why the statement, 'A country's economy is worth £1 billion per year and its national debt is £2 billion, so the debt is worth more than the entire economy' is wrong, without referring to further concepts from economics ♦ determine whether the units of measure used in a formula are inconsistent and, if they are inconsistent, deduce that the formula is not a valid model. For example: — explain why the statement, 'The time taken for my journey to school is equal to ten times the number of red traffic lights minus the speed limit' is not valid

Mathematical modelling		
Skills	**Explanation**	**Examples**
	♦ evaluating the effects of error and tolerances within mathematical models: — calculating the limits for compound measures, for example velocity, density, or journey times — determining if a process is within tolerance	♦ given a formula relating two or three variables, estimate the absolute or relative error in the dependent variable given the absolute or relative error in the independent variable(s). For example: — given the formula $P = 2l + 2b$, estimate the absolute error in P given the absolute errors in l and b — given the formula $v = \frac{d}{t}$, with the information that there is up to a 10% error in d and up to a 5% error in t, estimate the relative error in v ♦ understand the difference between an absolute error and a relative error (an example of which is an error expressed as a percentage) and convert between them. For example: — if the circumference of a circle is 30 cm and the relative error is 10%, the absolute error is 3 cm ♦ given a formula relating two variables, estimate the tolerance (maximum permitted error) in the independent variable required to ensure that there is no more than a given absolute or relative error in the dependent variable. For example: — given the formula $C = 2\pi r$, and the information that C must equal 10 with a relative error of no more than 10%, estimate the maximum absolute error in r ♦ distinguish between the precision and the accuracy of a mathematical statement, and state final answers to an appropriate level of precision. For example: — know that the statement, 'The current population of Scotland is 26 765 213' is very precise but not accurate, while the statement,

Mathematical modelling		
Skills	**Explanation**	**Examples**
	♦ evaluating and interpreting the output of mathematical models	‘The current population of Scotland is between 5 and 6 million’ is accurate but not very precise — know that final results should not be quoted to a higher precision than the data in a problem ♦ given a short passage (for example in the style of an advertisement or a news article) that summarises a model prediction or a statistical finding, discuss how accurate or plausible the summary is with reference to: — consistency of units of measure — the likely accuracy and the claimed precision of statements, for example an advertisement claiming ‘21 365 people in Glasgow currently have a cold’ — extrapolation beyond the likely validity of a model, for example a news article claiming ‘1508 candidates sat National 5 Applications of Mathematics in 2017 and 4458 candidates sat it in 2019, so National 5 Applications of Mathematics is expected to overtake National 5 English, with 45 593 candidates, by 2033’ — claims that are physically implausible (predictions of negative populations) or unreasonable (a news article claiming that users of mobile phones are on average one standard deviation more intelligent than the general population) ♦ given model predictions or data in the form of a graph, table or formula, discuss why the model takes the form it does, and use this model to make predictions

Mathematical modelling		
Skills	**Explanation**	**Examples**
	♦ analysing mathematical models and suggesting possible improvements	♦ given a model that makes inaccurate or implausible predictions, identify the modelling assumptions that are at fault, and suggest how the model might be changed. For example: — a rabbit population introduced to a new area might initially grow exponentially, but it cannot continue to do so forever. A better model might make the growth depend on the supply of food, so the population eventually approaches a limiting value ♦ given two different models for a given phenomenon, discuss which is more plausible under given circumstances. For example: — discuss whether an exponential or a linear growth or decay law is more appropriate to describe a population of bacteria
Using software effectively in calculations	♦ using software to carry out calculations in a way that another independent user can easily understand and check, including: — incorporating clear and consistent presentation — setting up key variables before using them in calculations	♦ use basic spreadsheet functions, for example fill down cells, absolute cell references, and copying and renaming sheets ♦ include comments on formulae in spreadsheets or programs to allow the reader or user to interpret them ♦ choose suitable names or symbols for variables and functions that help the reader or user to interpret them ♦ work through examples of spreadsheets or programs written with and without good practice ♦ check the validity of examples of spreadsheets or programs with and without comments Note: candidates should have experience of using spreadsheets, should be able to create a spreadsheet from scratch, and develop and adapt

Mathematical modelling		
Skills	**Explanation**	**Examples**
		existing spreadsheets. The question paper does not require candidates to use advanced spreadsheet techniques.
	♦ understanding and applying the following knowledge: — editing and sorting data — using standard functions to generate formulae — producing output — creating and labelling charts and graphs	♦ given raw data in a suitable format, for example .xls or .csv file: — supply appropriate column and row headings — sort data according to one criterion or multiple criteria — combine data from more than one source document — enter and edit data manually ♦ use the following spreadsheet functions: — SUM — PRODUCT — IF — AND/OR — ROUND — ABS — INT — GOAL SEEK — AVERAGE — MIN — MAX — MEDIAN — COUNTIF — STDEV — PEARSON

Mathematical modelling		
Skills	**Explanation**	**Examples**
		♦ extract basic statistical information from a data set using standard spreadsheet functions (or their equivalents in, for example, RStudio and Minitab) ♦ implement models based on recurrence relations. For example: — set up a spreadsheet that describes the effect of interest payments, deposits and withdrawals on a bank balance, and use it to demonstrate how the account is affected by a change in the interest rate ♦ use a spreadsheet or other software to generate plots, such as: — scatter plots and line graphs — bar charts — histograms with correct axis labelling and attention to accessibility (for example clear text and avoiding unnecessary colour-coding) and export these plots in a suitable form (for example bitmap or vector graphics files) to incorporate in a report

Statistics and probability		
Skills	**Explanation**	**Examples**
Applying statistical skills to basic probability	♦ constructing tree diagrams and Venn diagrams ♦ carrying out basic calculations involving the combination of events, where information may be displayed in tables or graphs, such as tree diagrams and Venn diagrams	♦ demonstrate knowledge and understanding of basic probabilities of independent events ♦ interpret information represented in tables or graphs, such as tree diagrams and Venn diagrams ♦ derive conditional probabilities from tree diagrams and Venn diagrams (using AND and OR conditions) ♦ determine combinations of independent events. For example, what is the probability that someone is good at mathematics and has yellow as their favourite colour?
Applying statistical literacy skills to data	♦ understanding the following: — types of data — populations and samples — outliers — gathering data and associated issues	♦ identify data types (categorical or numerical — discrete and continuous) ♦ explain the difference between a population and a sample, and when random samples are essential, for example opinion polls or prevalence estimates ♦ identify the biases that non-random samples may introduce, for example with online questionnaires — only people with internet access or strong views are likely to respond ♦ explain the influence of outliers on a data set; their importance, and whether it is appropriate to exclude them from specific analyses. For example, in studies used to compute reference ranges (for example infant growth charts) data gathering and entry errors (for example negative age) can be removed if the values are impossible, or would have a misleading influence on the results

Statistics and probability		
Skills	**Explanation**	**Examples**
	♦ constructing and interpreting statistical diagrams, for example: — frequency tables — stem-and-leaf diagrams — pie charts — bar charts — box plots — contingency tables — histograms — misleading graphs	♦ in the context of large data sets from a variety of sources: — use statistical software to create tables and graphs of data with appropriate formatting — clear title and axes labels, ensuring scales are appropriate — select the appropriate graph for each type of data, for example pie charts and bar charts for categorical data, histograms and box plots for numerical data, or scatter plots and contingency tables for bivariate data — explain the information displayed in a graph and/or table
	♦ interpreting the distribution of data, with particular reference to symmetry, normality, and skewness	♦ use a histogram to determine whether data is normally distributed, skewed with a tail to the left, or skewed with a tail to the right Note: candidates do not need to know how to test for skewness.
	♦ deriving, understanding, and interpreting sample measures of location and dispersion, including mean and standard deviation, and median and interquartile range	♦ use statistical functions in software to generate appropriate descriptive statistics: — numbers and proportions within each level of a categorical variable or discrete numerical variables — means and standard deviations of normally distributed numerical data — medians and interquartile ranges for skewed numerical data ♦ interpret tables and graphs, making reference to appropriate formats and misleading representations

Statistics and probability		
Skills	**Explanation**	**Examples**
		♦ compare and comment on the differences between two groups in a data set using a graphical display (for example box plots) or descriptive statistics, for example: — higher proportion of vegan restaurants in 2020 compared to 2018 — wider spread of salaries in NHS England than NHS Scotland — higher median house price in Aberdeen compared to Inverness
Applying statistical skills to correlation and linear regression	♦ interpreting and constructing scatter plots ♦ using simple linear regression ♦ interpreting the slope and intercept parameters in relation to data ♦ using linear models for prediction ♦ assessing the accuracy of predictions ♦ understanding and interpreting correlations ♦ understanding the applicability of Pearson's product-moment correlation coefficient ♦ exploring trends in data, for example seasonality	♦ use software to produce scatter plots (adhering to the formatting mentioned above) ♦ describe the relationship or trend shown by the scatter plot, for example approximately linear and increasing, approximately linear and decreasing, or no obvious linear relationship ♦ compute the correlation and interpret it in the context of the data. For example, there is a strong negative linear association between the two variables because $r = -0 \cdot 7, p < 0 \cdot 05$ ♦ understand that a correlation does not imply causation. For example, a positive correlation between incidents of knife crime and global temperatures may exist, but this does not imply that there is a relationship ♦ understand the influence of outliers in correlation — that the presence of outliers may reduce the correlation ♦ use software to fit a linear regression model, where appropriate ♦ interpret the slope and intercept parameters in the context of the data ♦ use the linear regression model to predict the dependent variable and comment on the accuracy of the prediction:

Statistics and probability		
Skills	**Explanation**	**Examples**
		— predictions need to be within the range of the data used to make the model — the model must be a strong linear model (a significant correlation) — prediction intervals are not required, but candidates may comment on them
Applying statistical skills to data analysis, interpretation and communication	♦ formulating research questions ♦ interpreting and reporting the results of a hypothesis test ♦ generating, understanding, and interpreting confidence intervals	♦ explain the reasoning behind hypothesis testing ♦ explain the ideas of a null and alternative hypothesis and determine these for a given study: — the p-value is the probability of getting data as extreme as those actually observed in the experiment if the null hypothesis were true — use the p-value to explain the conclusion of the test ♦ use statistical software to generate confidence intervals ♦ understand confidence intervals and why they are important: — they give a range of uncertainty seen in the parameter estimates (for example mean or proportion) of the study — wider confidence intervals indicate more uncertainty and narrower confidence intervals indicate less uncertainty — literal interpretation of 95% confidence intervals for a mean is that if you repeated the study 100 times, 95 of these times the estimated population mean would lie within the interval — use an online simulator to improve understanding of confidence intervals, for example https://shiny.rit.albany.edu/stat/confidence/

Statistics and probability		
Skills	**Explanation**	**Examples**
	♦ performing simple analysis using t-tests and paired t-tests ♦ using z-tests for two proportions	♦ know when it is appropriate to use a t-test, a paired t-test or a z-test for two proportions to address a research question ♦ perform a t-test, a paired t-test or a z-test for two proportions on large data sets and interpret the results of the test ♦ know what type I and type II errors are: — type I: rejecting the null hypothesis when it is true — type II: failing to reject the null hypothesis when it is false and explain the implications of these on a hypothesis test
	♦ understanding how errors can arise in statistical testing, including confounding variables	♦ discuss the results of the test in the context of the research question, including the possibility of type I and type II errors and the implications of these ♦ discuss confounding variables. For example: — an analysis may show that males are more likely to die younger than females — if males are more likely to smoke and, therefore, die younger, then gender is confounded with smoking — it may be the effect of smoking, rather than gender, that causes males to die younger, so further analysis is required
	♦ interpreting and relating results of a hypothesis test to the original research question	♦ decide if there is a significant difference in the results of a t-test ♦ interpret the difference within the context of the research and decide if the difference is worthwhile in terms of the context of the research ♦ explain how the results of the test should be interpreted in terms of the effect estimated. For example, the mean difference from a two-sample t-test could be £100:

Statistics and probability		
Skills	**Explanation**	**Examples**
		— if this was the difference in a weekly shop for the same products between two supermarkets, then it would be important and helpful to consumers — if the average annual fuel cost to an airline was £2·4 billion and by changing to a different fuel provider the airline saved on average £100, this saving would be totally negligible

Finance		
Skills	**Explanation**	**Examples**
Applying mathematical skills to calculating present and future values of monetary payments		This section covers the fundamental skills related to interest rates and present and future values of money that apply to particular financial contexts in the sections that follow. In this course, the interest rates applied to capital amounts are effective rates of interest, calculated on a compound basis. For clarity, other terminology (such as APR, which has multiple definitions) should not be used.
	♦ understanding the concept of capital and interest and performing calculations involving effective rates of interest, including: — interest rates that are fixed or vary over time — expressing interest rates in different time frequencies	Candidates could look at interest rates available in different contexts (for example bank accounts, loans, or insurance savings products) and compare these. Candidates could move between equivalent interest rates of different frequencies, for example converting annual effective rates of interest to monthly effective rates of interest, and vice versa. They should be able to perform calculations involving interest rates that are fixed or vary over time in a predetermined way.
	♦ calculating the present value and accumulated value of a single payment and a series of payments under the following scenarios: — regular, level payments — irregular and ad hoc payments — regular payments that increase or decrease by a fixed amount or fixed proportion each time period	Candidates could calculate the accumulation of a set of payments at a future time (using a calculator or a spreadsheet, where relevant). This could be taught in the context of a savings bank account, focusing on savings products available in the marketplace to achieve savings targets. Candidates could apply the inverse operation of calculating present value, involving calculating the single payment (using a calculator or spreadsheet) or the series of payments (by spreadsheet using the Goal Seek function or otherwise) needed at earlier times to accumulate

Finance		
Skills	**Explanation**	**Examples**
	— payments that are deferred for some period of time — an effective rate of interest that is fixed or varies over time, including at a different frequency to that of the payments	amount(s) of money needed at future time(s). This could be taught in the context of a particular savings goal (for example a deposit for a house, a new car, or for retirement) or a loan (for example calculating the loan amount as the present value of the repayments). Candidates could perform calculations involving payments of all specified frequencies and patterns, including exchange rates between currencies. They could evaluate times that these different payment patterns may be useful, for example deferring repayments during a repayment holiday on a mortgage. Candidates could perform calculations involving effective rates of interest that change over time. This could be in the context of actual interest rate changes to variable interest financial products. In relation to all of the above, candidates could perform: ♦ calculations, with a calculator, involving one or more payments made at a single time, or at up to five different (regular or ad hoc) times ♦ spreadsheet calculations involving payments made at a range of (potentially many) different times These ideas could also be taught using the context of the financial products in the next section.

Finance		
Skills	**Explanation**	**Examples**
Applying mathematical skills to solving problems related to personal financial products and transactions and analysing the results	**Credit cards and loans** ♦ understanding the purpose of credit cards and loans ♦ solving and analysing problems relating to credit cards and loans, including: — the effective rate of interest for a loan or credit card — constructing a schedule of repayments for a loan or credit card — calculating revised figures as a result of alterations, for example to loan terms, interest rates, and overpayment ♦ analysing the risks associated with credit cards and loans	This section covers a range of savings and lending products and applies concepts from the previous section to calculations involving them. Candidates could perform calculations (using a calculator and spreadsheets) for loans in all forms, for example credit cards, mortgages, personal loans, payday loans, or bank overdrafts. These could include: ♦ a single repayment of both interest and the capital amount of the loan at the end of the loan term ♦ only regularly repaying interest, with the capital amount of the loan repaid at the end of the loan term ♦ regularly repaying capital and interest over time using different forms of payment, for example level, increasing or decreasing, or deferred repayment holidays Candidates could use a spreadsheet to construct a loan schedule for repaying borrowings for each time period, showing the: ♦ repayment amount ♦ interest content (how much of that repayment is made up of interest) ♦ capital content (the remainder of the repayment that is made up of repayment of capital) ♦ loan outstanding (the amount of the loan remaining after the repayment has been made)

Finance		
Skills	**Explanation**	**Examples**
		Candidates could use the loan schedule constructed on the spreadsheet to: ♦ carry out calculations to find a variety of unknown quantities, for example the repayment amount, loan term, or effective interest rate ♦ solve problems using the Goal Seek function of a spreadsheet (for example where the repayment amount is the unknown) Candidates could complete calculations associated with changes to the loan during its term (for example changes of effective interest rate, overpayment, repayment holidays, or changes in loan repayment term). They could evaluate the impact of changes, for example use the spreadsheet to determine the loan amount outstanding at the date of change and use this to calculate the revised repayment needed after the change takes place. Candidates could evaluate the risks associated with borrowing in different contexts, both for the borrower (for example repayments becoming unaffordable) and the lender (for example losses resulting from the borrower defaulting on their loan).
	Savings products ♦ understanding the purpose of savings products ♦ solving and analysing problems relating to savings products, including saving for a	Candidates could calculate (using a calculator and spreadsheets): ♦ the accumulated amount of money in a savings product (for example a bank account) over time

Finance		
Skills	**Explanation**	**Examples**
	specific goal (for example regular or irregular pension contributions saving towards retirement) or an unspecified goal (for example general savings for no specific purpose) ♦ analysing the risks associated with savings products **Insurance** ♦ understanding the purpose of insurance products ♦ analysing the risks associated with insurance products	♦ the payment(s) or contribution(s) that must be made to a savings account to reach a savings goal, for example a pension for retirement ♦ the impact of payment(s) or contribution(s) on the time taken to reach a savings goal Candidates could evaluate the risks associated with saving (or not saving), for example inability to reach a savings goal. Candidates could demonstrate their understanding of the personal insurance products available, including buildings insurance, contents insurance, life insurance, car insurance, pet insurance, or travel insurance. They could explain why these products are needed and the risks associated with not buying them. For all of these financial products, candidates could investigate the products available in the real world, and understand how these products work, the calculations required, and the risks associated with them.
Applying personal financial planning skills	♦ understanding the following monetary concepts, applying these in financial calculations, and interpreting their impacts: — taxation systems — inflation and purchasing power of money; comparing alternative strategies that individuals could take in	Candidates could demonstrate an understanding of, and be able to complete calculations (including using spreadsheets) involving: ♦ salaries, for example basic pay, overtime, or bonus ♦ pension contributions, for example superannuation ♦ income tax ♦ National Insurance

Finance		
Skills	**Explanation**	**Examples**
	relation to their financial planning (for example borrowing money)	♦ tax on products purchased, for example value-added tax (VAT) on goods and services, Land and Buildings Transaction Tax and stamp duty on property This includes where tax rates are applied in bands based on level of income. Candidates could compare real-world tax systems, for example Scotland and England, or Scotland and Germany. Candidates could perform calculations relating to the impact of inflation in reducing the purchasing power of money over time, for example calculate how much more or less a particular amount of money could buy at two different times as a result of inflation. Candidates could study real-world rates of inflation as measured by inflation indices, for example RPI.
	♦ analysing and interpreting the risks associated with financial planning strategies	Candidates could perform calculations (including using spreadsheets) to evaluate alternative strategies relating to the use of money and financial planning, and demonstrate their understanding of the risks associated with these, for example: ♦ spending money versus saving money ♦ alternative uses for money in the bank, for example calculating and discussing the comparative impact on the balance in a bank account ♦ alternative ways of funding purchases, for example using savings versus using loans ♦ alternative strategies for saving towards a goal, for example performing calculations where money is saved earlier versus later

Planning and decision making		
Skills	**Explanation**	**Examples**
Understanding and applying project planning and decision making	♦ representing compound projects by activity networks using activity-on-node representation, for example Programme Evaluation and Review Technique (PERT) charts	♦ use PERT charts as a method to display activities within a project with a network of nodes and arrows ♦ analyse the activity times to determine the activities along the critical paths (the chart can be used to track the activities that must be completed before and after each node) ♦ calculate slack time (the leeway to fall behind within non-critical paths)
	♦ using systematic methods to find early and late times for activities, and then identifying critical activities and finding critical paths	♦ complete or create a PERT chart (see example after this table): — provide details about scheduling activities (including earliest start times, latest finish times, and float — or slack time — available) — identify the critical path ♦ review or interpret a completed PERT chart for a project and provide advice about costings associated with the whole project or part of a project
	♦ using Gantt charts to represent project activities	Candidates could use Gantt charts to display a schedule of tasks. A Gantt chart contains bars that represent each activity within a project. The length of each bar represents the relative length of the activity. Candidates could explore the following advantages of a Gantt chart: ♦ simplicity ♦ the bar lengths indicate the relative length of time for each activity, so it is clear to see the time it will take to the complete activities ♦ activity overlaps are clear ♦ activities in a critical sequence can be identified ♦ the length of a project can be calculated

Planning and decision making		
Skills	**Explanation**	**Examples**
		Candidates could convert a PERT chart to a Gantt chart, and vice versa. Candidates could identify the similarities and differences between Gantt and PERT charts: ♦ Activities are represented by bars in a Gantt chart and by nodes in a PERT chart. ♦ The length of the arrow on a PERT chart is not related to activity duration. ♦ Nodes on a PERT chart are called 'events' (assigned activities or tasks) and indicate a completed activity. ♦ The layout of the nodes on a PERT chart indicates the precedence order of the activities and which activities need to be completed before a new activity can start. ♦ Gantt charts do not indicate precedence order. Candidates could explore the reasons for using PERT charts over Gantt charts: ♦ identifying the order of precedence is easy ♦ identifying the critical path and critical activities is easy ♦ determining slack time is easy Candidates could analyse the output from project management software (for example Microsoft Project or equivalent).

Planning and decision making		
Skills	**Explanation**	**Examples**
	♦ understanding and interpreting risk by calculating the expected value of costs and benefits of decisions	Candidates could identify the four main factors a systems analyst (or project leader) must consider for a specific project: ♦ reasons for initiating a project (solving a problem or improving a system) ♦ feasibility of a project (cost-benefit analysis) ♦ planning project activities ♦ controlling project activities and project team members
	♦ applying expected value to real-life contexts and understanding this is an important part of decision making	Candidates could calculate expected value. Expected value is the difference between expected profit and expected costs. Expected profit is the probability of receiving a certain profit multiplied by the profit. Expected cost is the probability that a certain cost will be incurred multiplied by the cost.

Activity network and Gantt chart example

Candidates could create forward and backward scan diagrams based on a precedence table.

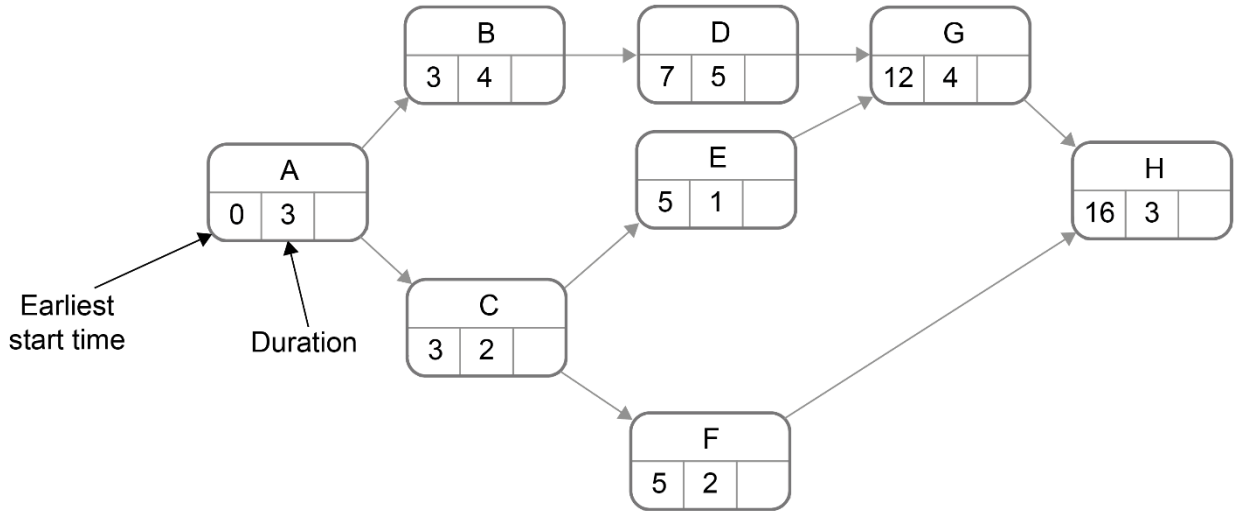
Activity	Predecessors	Duration
A	-	3
B	A	4
C	A	2
D	B	5
E	C	1
F	C	2
G	D, E	4
H	F, G	3

A forward scan shows the earliest possible start time for each activity. Enough time must be given to complete each activity; therefore, the quickest time is always the largest value used.

The following table shows the complete process.

Activity	Duration	Predecessors	Predecessor earliest start	Predecessor duration	Activity earliest start
A	3	-	-	-	0
B	4	A	0	3	0 + 3 = 3
C	2	A	0	3	0 + 3 = 3
D	5	B	3	4	3 + 4 = 7
E	1	C	3	2	3 + 2 = 5
F	2	C	3	2	3 + 2 = 5
G	4	D E	7 5	5 1	7 + 5 = 12 5 + 1 = 6
H	3	F G	5 12	2 4	5 + 2 = 7 12 + 4 = 16

The corresponding activity network is shown below.

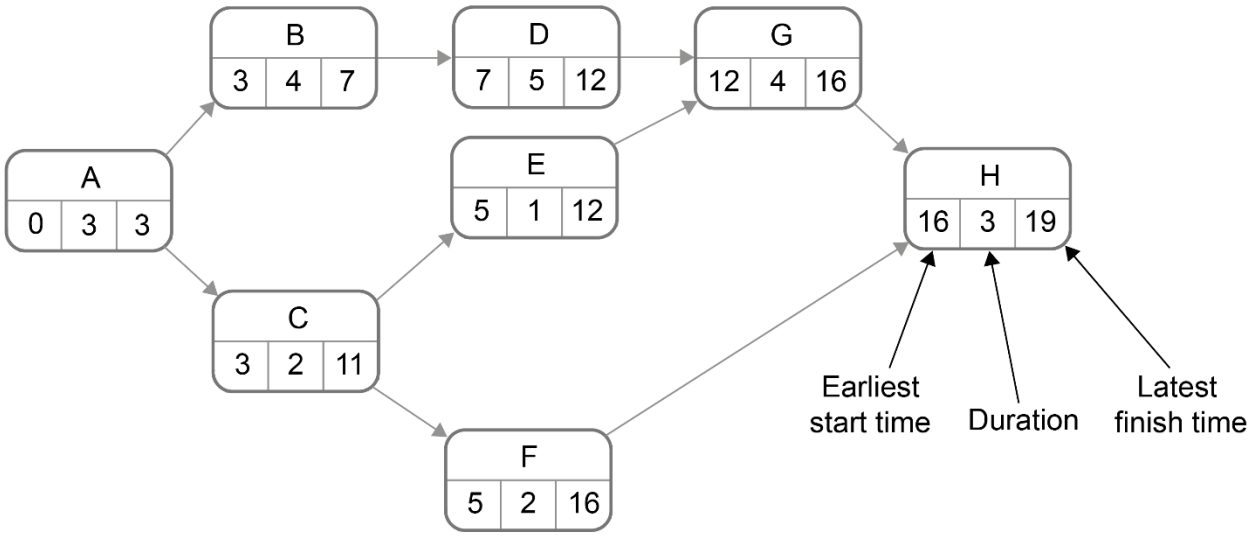


A backward scan shows the latest time that an activity can finish without extending the length of the critical path. When conducting a backward scan, it is always the smallest value that is used.

The following table shows the complete process.

Activity	Duration	Successors	Successor latest time	Successor duration	Activity latest time
H	3	-	-	-	19
G	4	H	19	3	19 − 3 = 16
F	2	H	19	3	19 − 3 = 16
E	1	G	16	4	16 − 4 = 12
D	5	G	16	4	16 − 4 = 12
C	2	E F	12 16	1 2	12 − 1 = 11 16 − 2 = 14
B	4	D	12	5	12 − 5 = 7
A	3	B C	7 11	4 2	7 − 4 = 3 11 − 2 = 9

The activity network can now be amended to show the latest finish times.

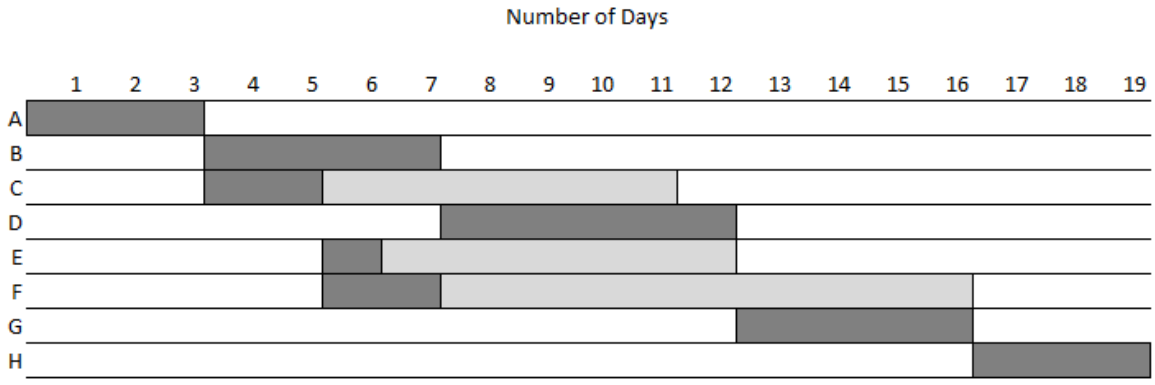


A critical activity is one where:

Latest finish time − duration − earliest start time = 0.

The critical path for this network is ABDGH.

This activity network can be represented in a Gantt chart as shown.



Float (or slack time) is the amount of time that an activity can be delayed without affecting the project end date.

The critical activities are represented by dark-grey bars. They have zero float. For the other activities, the light-grey bars indicate the length of time the activity can float.

Appendix 3: question paper brief

The course assessment consists of a question paper and a project.

The question paper assesses the ability to:

- analyse complex real-life situations and problems involving mathematics and statistics, in familiar and unfamiliar situations
- select and apply mathematical and statistical skills from across the course to tackle real-life situations or problems
- communicate mathematical and statistical information appropriately
- use mathematical and statistical reasoning skills to draw conclusions or justify decisions
- employ software to model and analyse statistical, mathematical and financial problems

The question paper samples the 'Skills, knowledge and understanding' section of the course specification.

This sample draws on all of the skills, knowledge and understanding from each of the following areas:

- mathematical modelling skills
- financial skills
- statistical skills
- planning and decision-making skills
- numerical skills
- reasoning skills
- interpretation skills

Command words are the verbs or verbal phrases used in questions and tasks to ask candidates to demonstrate specific skills, knowledge or understanding. For examples of some of the command words used in this assessment, refer to the specimen question paper on SQA's website.

	Question paper
Time	2 hours and 30 minutes
Marks	80
Skills	The question paper allows candidates to demonstrate the application and extension of mathematical and statistical skills. The question paper gives candidates an opportunity to interpret and analyse real-life problems or situations, select appropriate strategies, carry out calculations and draw valid conclusions, or justify decisions. These skills may be facilitated by using appropriate software, as this allows more opportunity for application and reasoning.
Percentage of marks across the paper	Approximately 15–35% of the overall marks relate to mathematical modelling. Approximately 10–25% of the overall marks relate to statistics. Approximately 30–45% of the overall marks relate to finance. Approximately 10–25% of the overall marks relate to planning and decision making.
Type of question	The question paper contains short-answer and extended-response questions, which may be based on source material in a pre-released data booklet.
Type of question paper	The question paper is a structured question paper — a question-and-answer paper that has spaces for answers. Some questions will require candidates to use software. Candidates must print and submit their answers to these questions.
Proportion of level 'C' questions	Some questions use a stepped approach to ensure that there are opportunities for candidates to demonstrate their abilities beyond level 'C'. These questions require a greater depth of knowledge and understanding, as well as a higher degree of rigour and accuracy to obtain a complete solution. Approximately 65% of marks are available for level 'C' responses.

Administrative information

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History of changes

Version	Description of change	Date

Note: please check SQA's website to ensure to ensure you are using the most up-to-date version of this document.