FOR OFFICIAL USE

National
Qualifications
ADDITIONAL SPECIMEN

Mark

S844/76/01 Applications of Mathematics

Date — Not applicable

Duration — 2 hours 30 minutes

* S 8 4 4 7 6 0 1 *

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day Month Year

Scottish candidate number

Total marks — 80

Attempt ALL questions.

You may use a calculator.

To earn full marks you must show your working in your answers.

State the units for your answer where appropriate.

You should refer to the pre-release material for Higher Applications of Mathematics which you can access electronically.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting.

Questions 6 (b), (c) (i) and (c) (ii), 8 (a) (i), (b) and (c), 10 (a) (i), (c) and (d), and 11 (a) and (b) must be completed on software and then be printed.

Use **blue** or **black** ink.

Before leaving the examination room you must place this booklet and your printouts inside the clear envelope provided. You must give this envelope to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

* S 8 4 4 7 6 0 1 0 1 *

Information and instructions for candidates

The electronic files listed below are provided for you to use during this examination:

- **Q6 Carol's Gift** — a spreadsheet file containing 1 worksheet (Original Loan)
- **Q8 Biomass Data** — a spreadsheet file containing 1 worksheet (Biomass Data)
- **Q8 Biomass Answers** — a word processing file
- **Q10 Visits Abroad Data** — a spreadsheet file containing 1 worksheet (Visits Abroad Data)
- **Q10 Visits Abroad Answers** — a word processing file
- **Q11 Karen's Pension** — a spreadsheet file containing 2 worksheets (Pension Fund, Savings Account)

Your output from the statistical software in questions 8 (a) (i), (b) and (c) must be copied and pasted into the file **Q8 Biomass Answers** for printing. Your output from the statistical software in questions 10 (a) (i), (c) and (d) must be copied and pasted into the file **Q10 Visits Abroad Answers** for printing.

You must display your name, SCN and the question number on all electronic files for printing.

Use this table to make sure you have all the printouts required.

Question	Printout	Completed (✓)
6 (b)	Original Loan worksheet • value view • formula view	
6 (c) (i) and 6 (c) (ii)	Pay Lump Sum worksheet • value view • formula view	
8 (a) (i)	Scatter diagram	
8 (b)	Statistical software output	
8 (c)	Statistical software output	
10 (a) (i)	Statistical diagram	
10 (c)	Statistical software output	
10 (d)	Statistical software output	
11 (a)	Pension Fund worksheet • value view • formula view	
11 (b)	Savings Account worksheet • value view • formula view	

Attempt ALL questions

Total marks — 80

MARKS | DO NOT WRITE IN THIS MARGIN

1. Estimate the number of hours sleep a typical person in Scotland has during their lifetime.

State any assumptions you make. **4**

2. Zosia has a savings account. The effective rates of interest were as follows:

- 3% per **year** during calendar years 2017 and 2018
- 2% per **half year** from 1 January 2019 until 1 July 2020
- 1% per **month** from 1 July 2020.

She made a deposit of £500 into her savings account on 1 July 2017.

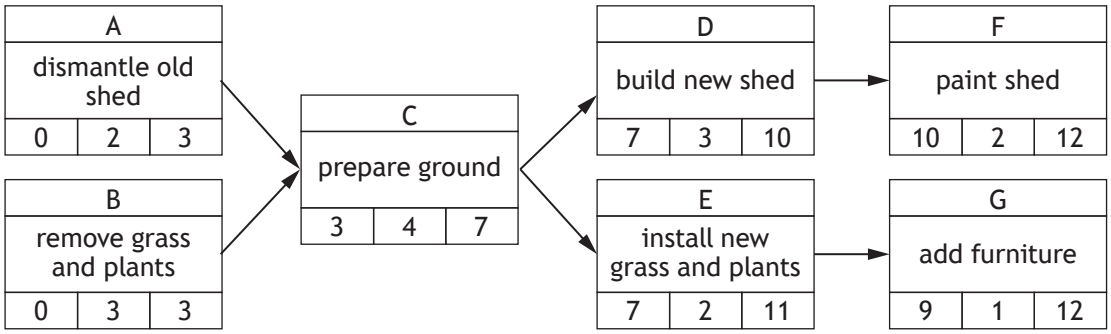
(a) Calculate the balance of Zosia's savings account on 1 January 2019. **1**

Zosia made further deposits and withdrawals as shown in the table.

Date	
1 January 2019	£100 withdrawal
1 January 2020	£150 deposit
1 January 2021	£80 withdrawal

(b) Calculate the balance of Zosia's savings account on 1 May 2022. **3**

3. The activity network for a garden renovation project is shown below.



(a) Explain, using examples from this project, the difference between an activity that is **essential** for the project and an activity which is **critical** for the project. **2**

(b) Describe the meaning of each of the three values in Activity C's node. **1**

(c) Produce a Gantt Chart for the above project. You do not need to include float times in your diagram. **4**

4. Joseph bought his flat 10 years ago for £100,000.

Joseph is buying a new home insurance policy. Some key points of the policy are:

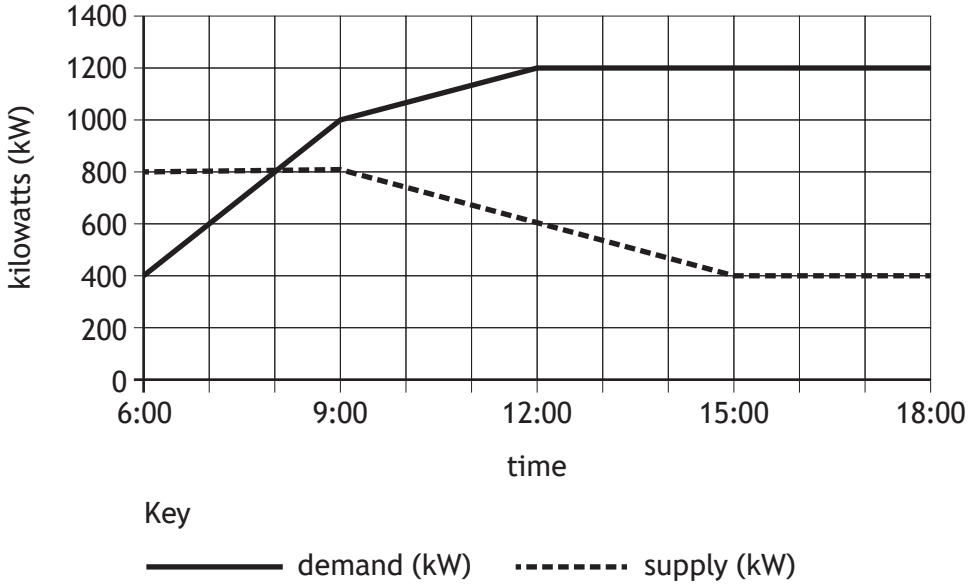
- Type of policy: Buildings and contents cover.
- Total value insured: £100,000.
- Term: 5 years.
- Coverage: The policy will pay out in part or in full, as necessary, up to the above amount, in the event of burglary or natural disaster (for example, flooding or earthquake).
- Annual premium: £300.

Give **three** reasons why Joseph may decide not to buy this insurance policy. **3**

5. An island generates its own electricity. It has a small wind farm and a diesel generator. The diesel generator is used when the demand for electricity exceeds the supply. The engineer who runs the system uses a mathematical model based on past data to predict supply and demand of electricity.

The rate at which electrical energy is supplied or demanded is measured in kilowatts (kW). The total amount supplied or demanded is measured in kilowatt-hours (kWh).

The graph **below** shows the predicted rate at which the wind farm can supply energy and the predicted rate of electricity demand over a 12-hour period.



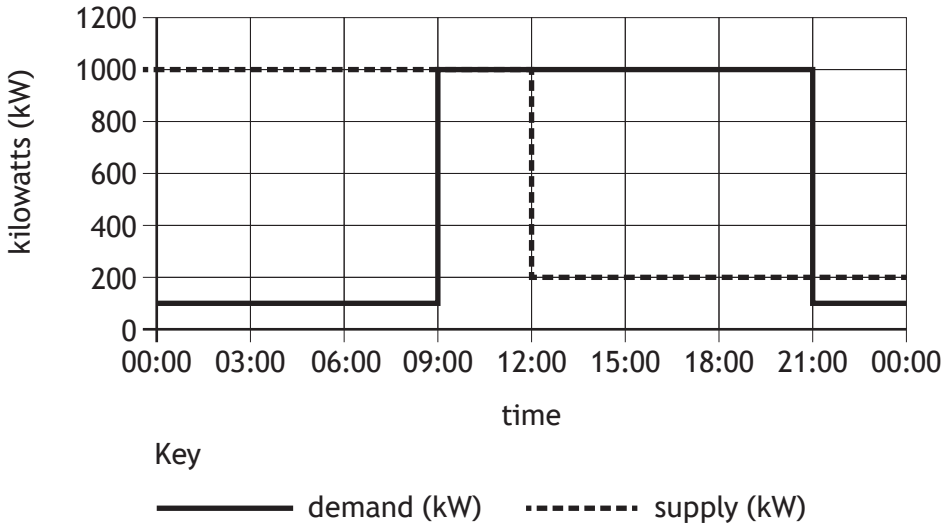
(a) (i) State the number of hours the diesel generator is required during this period. **1**

(ii) Determine the maximum rate at which the diesel generator should be able to generate electricity during this period. **1**

5. (continued)

The engineer designs an energy storage system, which will allow the islanders to store some of the energy supplied by the wind farm and use this energy when they need it.

The graph **below** shows the predicted rates of electricity supply and electricity demand over a 24 hour period.



(b) (i) Determine the total amount of electrical energy used over this period. **1**

(ii) Determine the minimum amount of energy the storage system must be able to store to meet the demand. **2**

[Turn over

6. You must refer to the spreadsheet file 'Q6 Carol's Gift' when answering this question. You must complete parts (b), (c) (i) and (c) (ii), using the spreadsheet file. Parts (a) and (d) must be completed in the answer spaces provided.

Carol has received a gift of £2500, and is considering what to do with it.

She has a savings account that pays interest at an annual effective rate of 1.25%.

(a) Calculate how much **interest** Carol would earn if she invested this gift in her savings account for 34 months. **2**

Carol also has a personal loan. She originally borrowed £8000 to be repaid by level monthly repayments for 48 months, with the first repayment made one month after she took out the loan. Interest is charged at an annual effective rate of 4.9%.

(b) Open the 'Original Loan' worksheet. Complete formulae in the loan schedule and calculate the level monthly repayment amount, and the final repayment amount. **4**

Carol has just made the 14th monthly repayment on the loan. She decides to find out the impact of using the £2500 gift as a lump sum payment to reduce the outstanding balance on her loan.

The loan provider agrees to recalculate a new level monthly repayment amount, to be paid in each of the remaining 34 months.

(c) (i) Copy the 'Original Loan' worksheet. Rename the copy to 'Pay Lump Sum'.

Adjust the 'Pay Lump Sum' worksheet as required, and hence calculate Carol's new level monthly repayment. **3**

(ii) On the 'Pay Lump Sum' worksheet, calculate how much Carol would save in interest payments by making this lump sum payment. **2**

(d) State one reason why Carol might choose to pay the gift into her savings account, rather than use it to reduce the balance on her loan. **1**

Print your answers to Q6 (b), (c) (i) and (c) (ii) in:

- value view
- formula view.

7. Ecologists are carrying out a survey of plants at the side of a road. The side of the road is 500 metres long.

To count the number of plant species, the ecologists divide the side of the road into strips 20 metres long and study a few of these strips in detail.

In a randomly selected strip they study, they count 30 different species of plant. One ecologist argues that this means that in total there should be 750 different species of plant at the side of the road.

(a) (i) Explain why this is likely to be an overestimate. **1**

(ii) Suggest briefly how you might go about getting a better estimate without studying every strip at the side of the road. **1**

Rare daffodils grow in a section at the side of the road which is 170 metres long. An ecologist counts 7 rare daffodils in a random patch 1 square metre in area. They estimate that the side of the road is on average 2 metres wide with an error of ± 0.4 metres.

(b) Estimate the total number of rare daffodils at the side of the road and give an estimate of the relative error in this number. **5**

[Turn over

8. You must refer to the spreadsheet file 'Q8 Biomass Data' when answering this question. You must complete parts (a) (i), (b) and (c) using **statistical software**. You must copy and paste your answers to parts (a) (i), (b) and (c) into the word processing file 'Q8 Biomass Answers'. Parts (a) (ii), (b), (c), and (d) must be completed in the answer spaces provided.

The UK has a varied mix of renewable technologies and fuels including biomass which is a key fuel source for the decarbonisation of electricity generation and heat provision. Woodchips are an example of a source of biomass.

The heat output of woodchips used to generate energy varies depending on moisture content. The data in the spreadsheet file shows moisture content (%) and the associated heat outputs (kilowatts) of various random samples of woodchip.

(a) (i) Construct a scatter diagram for the data. **2**

(ii) Make two comments about the scatter diagram. **2**

(b) Find the equation of the regression line of heat output on percentage moisture content. **2**

(c) Estimate the heat output of woodchips with a moisture content of 35% and interpret this estimate by referring to a prediction interval. **2**

(d) Explain the implication of your analysis for anyone intending to use woodchips as a source of heat. **1**

Print your answers to Q8 (a) (i), (b) and (c).

9. A TV production company is responsible for the delivery of a new quiz show to a national television channel.

If the production is delayed, the company will be charged an additional £10,000.

For the purposes of the cost benefit analysis, it is assumed that there are only two events that will cause a delay:

- 0.3 probability that a key member of staff will fall ill
- 0.1 probability that there will be equipment failure.

(a) Calculate the expected value of costs that should be considered for the cost benefit analysis. **3**

It is possible to use the following control measures:

- Control Measure 1 — Employ back up staff who can replace anyone unwell, at a cost of £1000.
- Control Measure 2 — Spend £3000 on an equipment inspection to ensure all equipment is functioning correctly.

(b) Calculate the expected value of costs if control measure 1 is taken. **1**

The expected value of costs if control measure 2 is taken is £6000.

(c) State which control measure(s) should be taken.

Give a reason to support your recommendation. **1**

[Turn over

10. You must refer to the spreadsheet file 'Q10 Visits Abroad' when answering this question. You must complete parts (a) (i), (c) and (d) using statistical software. You must copy and paste your answers to parts (a) (i), (c) and (d) into the word processing file 'Q10 Visits Abroad Answers'. Parts (a) (ii), (b) and (d) must be completed in the answer spaces provided.

The data in the spreadsheet file shows the number of visits abroad (in thousands) by UK nationals to various countries in 2018 and 2019.

(a) (i) Construct boxplots for the data. **1**

(ii) Make three comments about your diagram making specific reference to any unusual data. **3**

(b) Generate descriptive statistics to form a subjective impression of whether there is difference in average visitor numbers between years. **2**

(c) Comment on the assumption associated with the appropriate hypothesis test for this data. **1**

(d) Use a hypothesis test to determine if there is any statistically significant difference between visitor numbers in 2018 vs 2019. **3**

Print your answers to Q10 (a) (i), (c) and (d).

11. You must refer to the spreadsheet file 'Q11 Karen's Pension' when answering this question. You must complete parts (a) and (b) using the spreadsheet file. Part (c) must be completed in the answer space provided.

Karen decides to start saving regularly towards her retirement. She aims to retire from work on her 65th birthday.

Karen wants to estimate how much she will need to save by age 65 to cover her costs of living in retirement.

She expects these costs of living will be payable at the start of each month, from her 65th birthday, up to and including her 80th birthday. She estimates the costs will initially be £1500 at age 65 and will increase every month with inflation, at an effective rate of 2.5% per year.

Karen also expects that she will be able to earn an effective rate of interest of 4% per year on her savings during her retirement.

(a) Open the 'Pension Fund' worksheet. Complete the relevant formulae in the spreadsheet to show that she must save approximately £243,960 by her 65th birthday to cover her expected costs of living in retirement. **5**

Karen has just celebrated her 20th birthday, and her monthly salary is £2600, which is constant and paid to her at the start of each month. She plans to make regular level contributions to her savings directly from her salary, in order to meet her expected costs of living in retirement. She decides to make these contributions immediately when her salary is received, every month between now and age 65.

Karen expects to earn an effective rate of interest of 5% per year on her savings before retirement.

(b) Use the 'Savings Account' worksheet to calculate what proportion of her salary she must save each month to meet her expected costs of living in retirement. **7**

(c) Describe **two** risks that could result in Karen not having enough savings to cover her living costs in retirement. **2**

Print your answers to Q11 (a) and (b) in:

- value view
- formula view.

[END OF ADDITIONAL SPECIMEN QUESTION PAPER]

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS

National
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ADDITIONAL SPECIMEN

S844/76/11

Applications of Mathematics
Data booklet

Date — Not applicable

Duration — 2 hours 30 minutes

Pre-release material

This booklet will be issued to centres in advance of the date of examination.

Candidates will be issued with a clean copy of this booklet. Copies will be issued at the start of the examination session and collected at the end of the session. Candidates must not take their own copies of this booklet into the examination.

Centres should ensure that candidates are familiarised with any contexts and information contained in this booklet in preparation for the examination.

Some examination questions will be based on this material.

This booklet contains some helpful R commands. There is no other material for this examination.

S8447611

Some helpful R commands

Entering data to R Studio

To read in data from an Excel csv file called *excel_data.csv* to R Studio and name it `mydata`, first use the drop down menus in R Studio **Session > Set Working Directory > Choose Directory** to indicate the location of *excel_data.csv* on your computer. The following code will then read the data into R Studio:

```
mydata<-read.csv("excel_data.csv")
```

`attach(mydata)` — this adds the variable names

At the end of the analysis remember to use `detach(mydata)` to disassociate the variable names.

(a) Graphics

If you have the numeric variables X and Y:

`hist(X, main= "Title",xlab="x-axis label",ylab="Frequency")` — this produces a histogram of the variable named X, it adds a title and axis labels

`boxplot(Y, main="Title", ylab="y-axis label")` — produces a boxplot of the numerical variable Y

`boxplot(X,Y, main="Title", xlab="x-axis label", ylab="y-axis label", names=c("X","Y"))` — produces a comparative boxplot of the numerical variables X and Y

`plot(X,Y, main="Scatterplot of Y on X",xlab="x-axis label",ylab="y-axis label")` — produces a scatterplot of Y on X

If you have the categorical variable X:

`table(X)` — computes the number of observations in each level of the categorical variable X

`pie(table(X), main="Title")` — this gives a simple pie chart of the categories in variable X with the specified title

`barplot(table(X), main="Title", xlab="x-axis label", ylab="Frequency")` — this gives a bar chart of the categorical variable X with the required title and axis labels

(b) Descriptive Statistics

`mean(X)` — computes the mean of the numerical variable X

`sd(X)` — computes the standard deviation of the numerical variable X

`summary(X)` — computes the mean, median, minimum, maximum and upper and lower quartiles of the numerical variable X

`IQR(X)` — computes the interquartile range of the numerical variable X

`prop.table(table(X))` — returns the proportion of observations in each level of the categorical variable X

`prop.table(table(X))*100` — returns the percentage of observations in each level of the categorical variable X

`table(X,Y)` — produces a cross-tabulation between the two categorical variables X and Y

(c) Correlation and Regression

`cor.test(X,Y)` — computes the correlation between X and Y and performs a test of the null hypothesis of zero correlation

`lm(Y~X)` — fits a linear regression line to the data (lm command stands for linear model)

`abline(lm(Y~X))` — adds the least squares linear regression line to an existing scatterplot of Y on X

`summary(lm(Y~X))` — displays the coefficient of determination (R-squared)

To predict with your Linear Model:

`predict(lm(Y ~ X), newdata=data.frame(X=C),interval = "pred")` — computes the predicted value of Y when X=C along with a 95% prediction interval

(d) Hypothesis Testing

`t.test(X,Y)` — performs a two-sample t-test between X and Y

`t.test(X,Y,paired=TRUE)` — performs a paired t-test between X and Y

`prop.test(x = c(a, b), n = c(n1, n2))` — performs a two-sample test for equality of proportions

[END OF DATA BOOKLET]

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S844/76/01 **Applications of Mathematics**

Marking Instructions

These marking instructions have been provided to show how SQA would mark this specimen question paper.

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General marking principles for Higher Applications of Mathematics

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

For each question, the marking instructions are generally in two sections:

generic scheme — this indicates why each mark is awarded
illustrative scheme — this covers methods which are commonly seen throughout the marking

In general, you should use the illustrative scheme. Only use the generic scheme where a candidate has used a method not covered in the illustrative scheme.

(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

(b) If you are uncertain how to assess a specific candidate response because it is not covered by the general marking principles or the detailed marking instructions, you must seek guidance from your team leader.

(c) One mark is available for each •. There are no half marks.

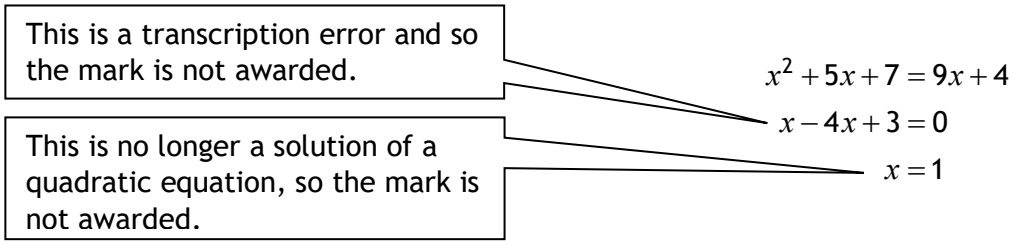
(d) If a candidate's response contains an error, all working subsequent to this error must still be marked. Only award marks if the level of difficulty in their working is similar to the level of difficulty in the illustrative scheme.

(e) Only award full marks where the solution contains appropriate working. A correct answer with no working receives no mark, unless specifically mentioned in the marking instructions.

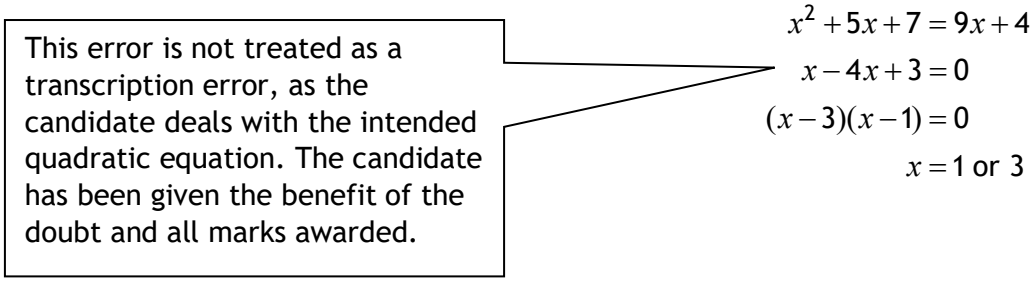
(f) Candidates may use any mathematically correct method to answer questions, except in cases where a particular method is specified or excluded.

(g) If an error is trivial, casual or insignificant, for example $6 \times 6 = 12$, candidates lose the opportunity to gain a mark, except for instances such as the second example in point (h) overleaf.

(h) If a candidate makes a transcription error (question paper to script or within script), they lose the opportunity to gain the next process mark, for example



The following example is an exception to the above



(i) **Horizontal/vertical marking**
If a question results in two pairs of solutions, apply the following technique, but only if indicated in the detailed marking instructions for the question.

Example:

	$\bullet^5$	$\bullet^6$
$\bullet^5$	$x=2$	$x=-4$
$\bullet^6$	$y=5$	$y=-7$

Horizontal: $\bullet^5$ $x=2$ and $x=-4$ Vertical: $\bullet^5$ $x=2$ and $y=5$
$\bullet^6$ $y=5$ and $y=-7$ $\bullet^6$ $x=-4$ and $y=-7$

You must choose whichever method benefits the candidate, **not** a combination of both.

(j) In final answers, candidates should simplify numerical values as far as possible unless specifically mentioned in the detailed marking instruction. For example

$\frac{15}{12}$ must be simplified to $\frac{5}{4}$ or $1\frac{1}{4}$ $\frac{43}{1}$ must be simplified to 43

$\frac{15}{0.3}$ must be simplified to 50 $\frac{4/5}{3}$ must be simplified to $\frac{4}{15}$

$\sqrt{64}$ must be simplified to 8*

*The square root of perfect squares up to and including 100 must be known.

(k) Do not penalise candidates for any of the following, unless specifically mentioned in the detailed marking instructions:

- working subsequent to a correct answer
- correct working in the wrong part of a question
- legitimate variations in numerical answers/algebraic expressions, for example angles in degrees rounded to nearest degree
- omission of units
- bad form (bad form only becomes bad form if subsequent working is correct), for example

  $(x^3+2x^2+3x+2)(2x+1)$ written as

  $(x^3+2x^2+3x+2)\times 2x+1$

  $=2x^4+5x^3+8x^2+7x+2$

  gains full credit

- repeated error within a question, but not between questions or papers

(l) In any 'Show that . . .' question, where candidates have to arrive at a required result, the last mark is not awarded as a follow-through from a previous error, unless specified in the detailed marking instructions.

(m) You must check all working carefully, even where a fundamental misunderstanding is apparent early in a candidate's response. You may still be able to award marks later in the question so you must refer continually to the marking instructions. The appearance of the correct answer does not necessarily indicate that you can award all the available marks to a candidate.

(n) You should mark legible scored-out working that has not been replaced. However, if the scored-out working has been replaced, you must only mark the replacement working.

(o) If candidates make multiple attempts using the same strategy and do not identify their final answer, mark all attempts and award the lowest mark. If candidates try different valid strategies, apply the above rule to attempts within each strategy and then award the highest mark.

For example:

Strategy 1 attempt 1 is worth 3 marks.	Strategy 2 attempt 1 is worth 1 mark.
Strategy 1 attempt 2 is worth 4 marks.	Strategy 2 attempt 2 is worth 5 marks.
From the attempts using strategy 1, the resultant mark would be 3.	From the attempts using strategy 2, the resultant mark would be 1.

In this case, award 3 marks.

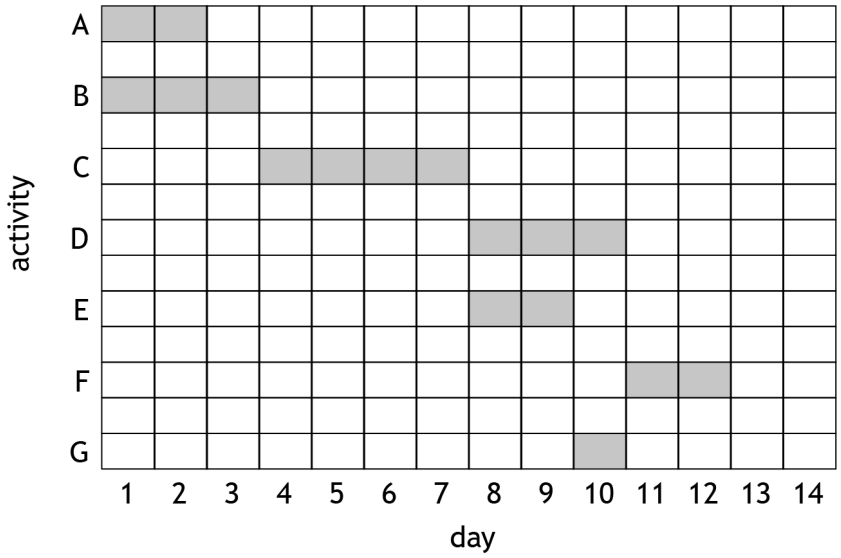
Marking instructions for each question

Question			Generic scheme	Illustrative scheme	Max mark
1.			$\bullet^1$ state an assumption about the number of hours sleep per night for an average person	$\bullet^1$ 6–10 hours	**4**
			$\bullet^2$ state an assumption about life expectancy for an average adult	$\bullet^2$ 65–90 years	
			$\bullet^3$ use a suitable number of days or weeks	$\bullet^3$ 365 days	
			$\bullet^4$ appropriate calculation leading to answer	$\bullet^4$ eg $8\times365\times75$ $=219000$ hours	
2.	(a)		$\bullet^1$ interpret time period and calculate accumulated value	$\bullet^1$ $500\times1.03^{1.5}=£522.67$	**1**
	(b)		**Method 1**	**Method 1**	**3**
			$\bullet^2$ calculate accumulated value on 1 January 2020	$\bullet^2$ $(522.67-100)\times1.02^2$ $=439.74\ldots$	
			$\bullet^3$ calculate accumulated value on 1 January 2021	$\bullet^3$ $(439.74\ldots+150)\times1.02\times1.01^6$ $=638.54\ldots$	
			$\bullet^4$ calculate accumulated value on 1 May 2022	$\bullet^4$ $(638.54\ldots-80)\times1.01^{16}$ $=£654.94$	
			Method 2	**Method 2**	
			$\bullet^2$ calculate accumulated value of balance on 1 January 2019	$\bullet^2$ $(522.67-100)\times1.02^3\times1.01^{22}$ $=558.30\ldots$	
			$\bullet^3$ calculate accumulated value of deposit on 1 January 2020	$\bullet^3$ $150\times1.02\times1.01^{22}=190.44\ldots$	
			$\bullet^4$ calculate accumulated value of withdrawal on 1 January 2021 and final balance	$\bullet^4$ $-80\times1.01^{16}=-93.80\ldots$ Balance $=£654.94$	

Question			Generic scheme	Illustrative scheme	Max mark
3.	(a)		•[1] essential: select activity and give definition •[2] critical: select activity and give definition	•[1] A, E or G: an activity which is needed for the project to be finished but tends to have more flexibility in time constraints. •[2] B, C, D or F: an activity in the 'critical path', any delays to these activities would cause a delay in the project end date.	**2**
	(b)		•[3] explanation of values	•[3] Activity cannot start before the end of day 3. The duration of the activity is 4 days. The latest possible finish time of the activity is the end of day 7.	**1**
	(c)		•[4] correct labels and scales on diagram •[5] task A or B plotted correctly •[6] all remaining tasks plotted correctly •[7] complete chart with linked tasks	•[4] 'Activity' and letters vertically, 'Day' and numbers horizontally •[5] Task A or B correct duration and position •[6] All tasks correct duration and position •[7] A&B to C, C to D&E, D to F and E to G	**4**

Notes:

1. Example solution:

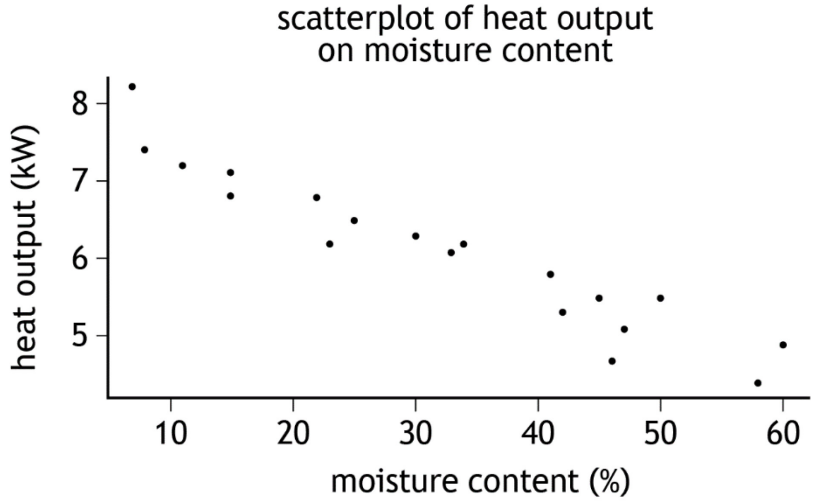


2. Activity A can be started 1 day later.
3. Activity E & G can be started 1 or 2 days later.

Question			Generic scheme	Illustrative scheme	Max mark
4.			•[1] give first reason •[2] give second reason •[3] give third reason	•[1, 2, 3] three reasons from for example • £100,000 is likely to be insufficient to cover the cost of the building due to inflation. • Insufficient amount to cover the contents, even if the property value has not increased over time. • The policy does not cover all perils: in particular, fire is not covered. • May prefer a premium which is payable monthly rather than annually, to spread the cost. • May not want to buy a policy covering such a long period of time.	**3**
5.	(a)	(i)	•[1] determine the number of hours where electricity demand exceeds electricity supply	•[1] From the graph, 'demand' crosses 'supply' at 0800 and remains higher until the end at 1800. The diesel generator is therefore needed for 10 hours.	**1**
		(ii)	•[2] determine the maximum difference between the rates of demand and supply.	•[2] The maximum difference between use and supply is $1200-400=800\,\text{kW}$, so this is the maximum rate required of the diesel generator.	**1**
	(b)	(i)	•[3] calculate the area under the 'demand' curve	•[3] The island uses $(100\times 9)+(1000\times 12)+(100\times 3)$ $=13200\,\text{kWh}$	**1**
		(ii)	•[4] identify storage needs •[5] calculate the storage	•[4] between 1200 and 2100. •[5] The energy required is $(1000-200)\times 9=7200\,\text{kWh}$	**2**

Question			Generic scheme	Illustrative scheme	Max mark
6.	(a)		•[1] calculate monthly interest rate •[2] calculate interest accrued over 34 months	•[1] 0.103…% or $1.0125^{\frac{\ldots}{12}}$ •[2] £89.56	**2**
	(b)		•[3] calculate monthly interest rate •[4] create formulae for interest, repayment and balance •[5] complete remainder of loan schedule for 48 months •[6] calculate monthly repayment and adjust final repayment	•[3] 0.399…% •[4] D13, E13 and F13 (see spreadsheet) •[5] check cells D60, E60, F60 (see spreadsheet) •[6] £183.49 and £183.28	**4**
	(c)	(i)	•[7] copy over spreadsheet and calculate outstanding balance •[8] change repayment amount at appropriate time •[9] calculate new monthly payments and adjust final repayment	•[7] £3322.54 •[8] C27 (see spreadsheet) •[9] £104.71 and 104.44	**3**
		(ii)	•[10] calculate total interest •[11] calculate interest saved	•[10] £628.73 •[11] £178.58	**2**
	(d)		•[12] state valid reason	•[12] eg money remains accessible	**1**

Question			Generic scheme	Illustrative scheme	Max mark
7.	(a)	(i)	$\bullet^1$ valid explanation	$\bullet^1$ eg This estimate assumes that each strip contains a different 30 species. It is likely that at least some species will be counted more than once.	**1**
		(ii)	$\bullet^2$ suggest a reasonable alternative.	$\bullet^2$ You could use an appropriate statistical sampling model to estimate the total number of species, treating the number from each strip as a separate sample from the same distribution of species.	**1**
	(b)		$\bullet^3$ calculate area of section and estimate number of blue daffodils	$\bullet^3$ Area $= 2 \times 170 = 340\,\text{m}^2$ $\Rightarrow$ number of blue daffodils can be estimated as $7 \times 340 = 2380$	**5**
			$\bullet^4$ estimate the relative error in the area	$\bullet^4$ The relative error in the area is $0.4 \div 2 = 20\%$	
			$\bullet^5$ identify the relative error in the density of daffodils	$\bullet^5$ Daffodils are discrete so we can estimate the error in the density as ± 0.5.	
			$\bullet^6$ estimate the relative error in the density of daffodils	$\bullet^6$ This is a relative error of $0.5 \div 7 = 7.14\ldots\%$	
			$\bullet^7$ calculate combined error	$\bullet^7$ We can estimate the total relative error in a product by adding the individual relative errors, obtaining $20 + 7.14\ldots = 27.14\ldots\%$	

Question			Generic scheme	Illustrative scheme	Max mark
8.	(a)	(i)	•[1] generate scatterplot •[2] appropriate title and axis labels	•[1] (See below) •[2] (See below)	**2**
Notes: 					
		(ii)	•[3] appropriate comment •[4] appropriate comment	•[3] eg linear relationship •[4] eg strong or negative association	**2**
	(b)		•[5] generate coefficient and intercept •[6] communicate equation	•[5] output from software (see below) •[6] $\text{heat output} = -0.06 \times \text{moisture content} + 7.96$	**2**

Notes:
`Coefficients:`
`(Intercept)  moisture`
`7.95778  -0.05751`					

	(c)		•[7] generate fitted value and prediction interval •[8] appropriate interpretation	•[7] (See below) •[8] The estimated heat output of woodchip with a moisture content of 35% is 5.9 kW, however the true value is likely to be between 5.3 and 6.6 kW.	**2**

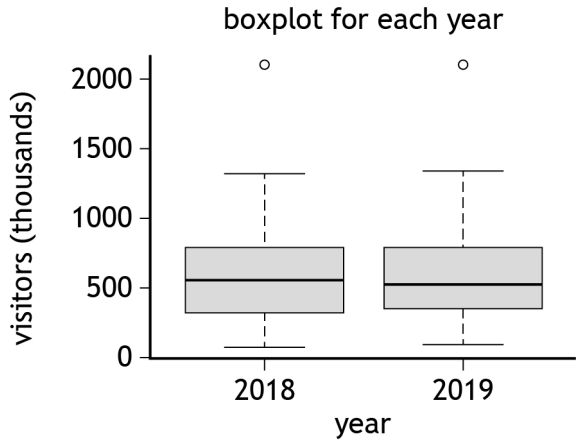
Notes:
`fit  lwr  upr`
`5.944833  5.266433  6.623232`					

	(d)		•[9] appropriate explanation	•[9] the lower the percentage moisture content of the woodchip the greater the heat output.	**1**

Question			Generic scheme	Illustrative scheme	Max mark
9.	(a)		•[1] calculate the probability of no issues occurring •[2] calculate the probability of at least one issue occurring •[3] calculate the expected penalty	•[1] $(1-0.3)\times(1-0.1)=0.63$ •[2] $1-0.63=0.37$ •[3] $0.37\times£10\,000=£3700$	**3**
	(b)		•[4] calculate expected penalty with control measure 1	•[4] $£1000+0.1\times£10\,000=£2000$	**1**
	(c)		•[5] decision with reason	•[5] Control measure 1 should be taken as it has the lowest expected cost	**1**

Question			Generic scheme	Illustrative scheme	Max mark
10.	(a)	(i)	•[1] generate comparable boxplots	•[1] (See below)	**1**

Notes:



		(ii)	•[2] comment on average •[3] comment on variability •[4] comment on any unusual data	•[2] eg The median number of visitors in 2019 appears lower. •[3] eg The consistency of visitor numbers between years appears similar •[4] The boxplots indicate one set of data that are outliers (Belgium)	**3**
	(b)		•[6] generate measures of location •[7] appropriate comment	•[6] (See below) •[7] eg There appears to be a difference in mean visitors between 2018 and 2019.	**2**

Notes:

```
     X2018           X2019
Min.   :  72.0   Min.   :  87.0
1st Qu.: 383.5   1st Qu.: 424.5
Median : 547.0   Median : 522.5
Mean   : 668.9   Mean   : 692.8
3rd Qu.: 783.0   3rd Qu.: 778.8
Max.   :2087.0   Max.   :2100.0
```

	(c)		•[5] appropriate comment	•[5] The differences must be approximately normally distributed	**1**

Question			Generic scheme	Illustrative scheme	Max mark
10.	(d)		•[8] perform appropriate test •[9] interpret result •[10] relate result to context	•[8] Paired t-test •[9] $p = 0.014$, reject the null hypothesis •[10] There is evidence of a difference in visitor numbers between 2018 and 2019 at the 95% level of significance.	**3**

Notes:

Paired t-test

data: X2018 and X2019
t = -2.7792, df = 15, p-value = 0.01404
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-42.185499 -5.564501
sample estimates:
mean of the differences
-23.875

Question			Generic scheme	Illustrative scheme	Max mark
11.	(a)		•[1] convert annual rates to monthly rates	•[1] 0.205…% and 0.327…% eg cell F4=(1+C4)^(1/12)-1	**5**
			•[2] calculate monthly pension required	•[2] cells C10—B190 eg cell C11 =ROUND($C$3*(1+$F$4)^A11,2)	
			•[3] create formula to calculate present value at retirement	•[3] eg cell D11 =ROUND(C11/(1+$F$5)^B11,2)	
			•[4] complete table for 180 months	•[4] check final cells C190 and D190	
			•[5] calculate fund required	•[5] £243,959.37	
	(b)		•[6] calculate monthly interest rate, and input savings required at age 65	•[6] 0.407…% and £242,959.37 (or answer carried forward from part (a)).	**7**
			•[7] create formula for first monthly payment in cell C10	•[7] cell C10=$C$5	
			•[8] create formula to accumulate monthly contribution to retirement in cell C11	•[8] cell D10 =ROUND(C10*(1+$F$4)^=(540-B10),2)	
			•[9] calculate number of months until retirement and complete table for 540 payments (NB: final payment is at time 539 months)	•[9] check final cells C549 and D549	
			•[10] calculate sum of monthly contributions	•[10] F6=SUM(C10:C550)	
			•[11] calculate monetary contribution	•[11] Cell C5 = £123.97 (using Goalseek or otherwise)	
			•[12] calculate regular contribution	•[12] cell B4 (4.77%)	
	(c)		•[13] describe one risk •[14] describe second risk	•[13] •[14] eg – Karen lives beyond age 80. – Karen's living costs are higher than assumed as a result of higher inflation than expected – Karen earns lower interest before or after retirement than she expected. – Karen loses her job or her salary is reduced and she cannot afford to save for retirement.	**2**

[END OF SPECIMEN MARKING INSTRUCTIONS]

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Change since last published:

Changes to details of **Some helpful R commands** in the data booklet.