National
Qualifications
ADDITIONAL SPECIMEN

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

Marking Instructions

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

SQA ©

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.

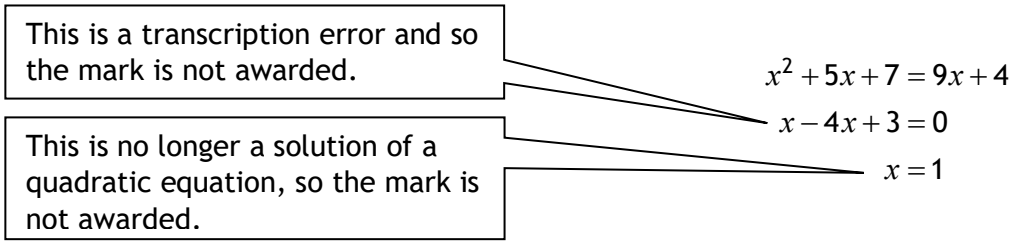
(d) If a candidate's response contains an error, all working subsequent to this error must still be marked. Only award marks if the level of difficulty in their working is similar to the level of difficulty in the illustrative scheme.

(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.

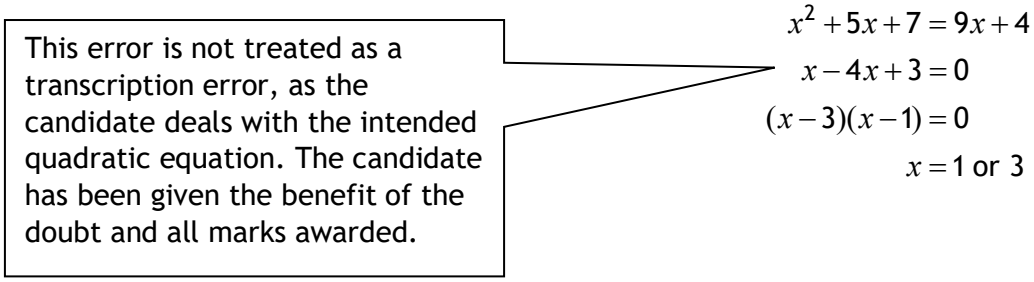
(f) Candidates may use any mathematically correct method to answer questions, except in cases where a particular method is specified or excluded.

(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.

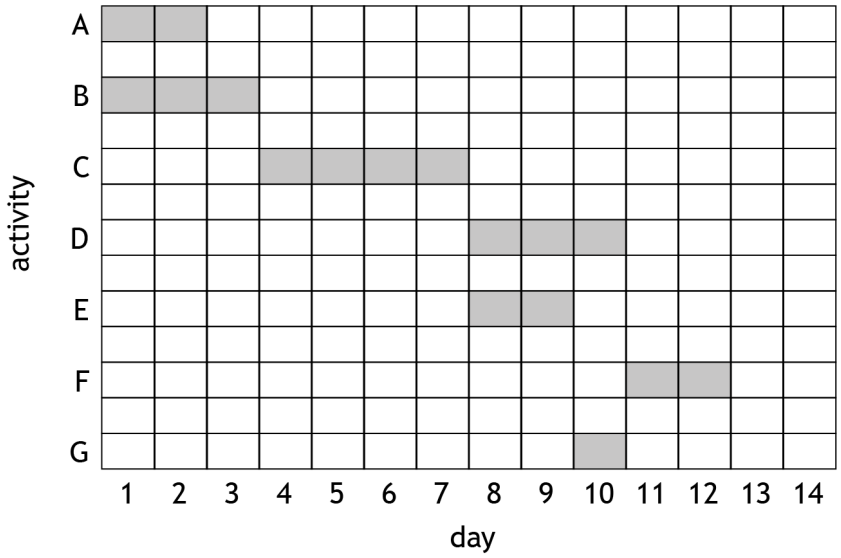
Marking instructions for each question

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:

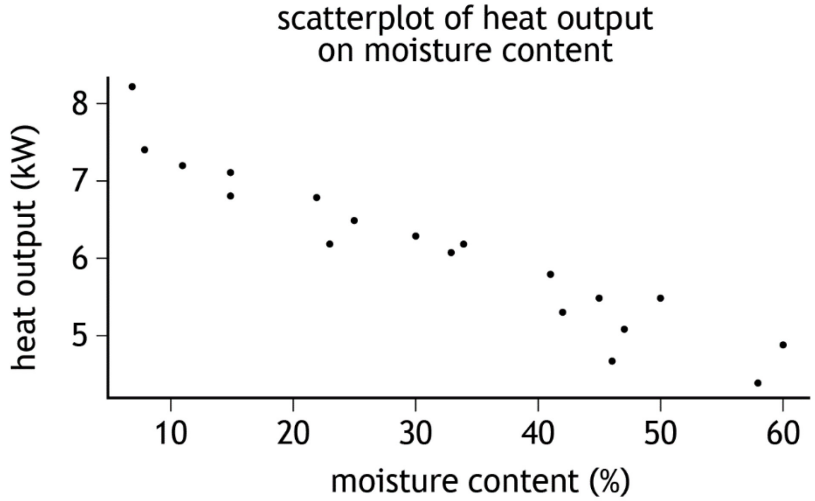


2. Activity A can be started 1 day later.
3. Activity E & G can be started 1 or 2 days later.

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**

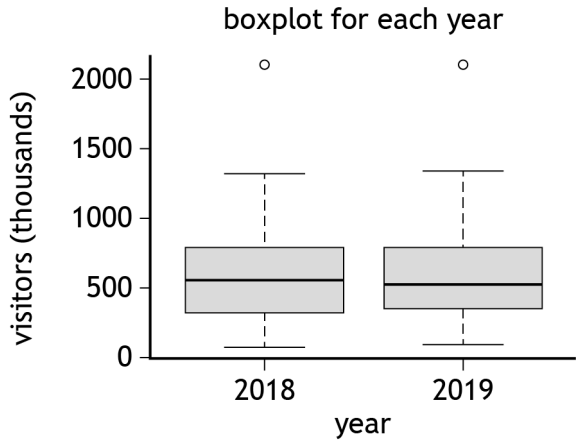
Notes:
`fit  lwr  upr`
`5.944833  5.266433  6.623232`					

	(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:

Marking instructions for questions 10 (b) and (c) swapped to match the question paper.