Topical Past Papers

AS & A Level Mathematics (9709) Paper 6

[Probability & Statistics 2]

Exam Series: February/March 2020 – October/November 2025

Format Type B:
Each question is followed by its answer scheme

Introduction

Each Topical Past Paper Questions Workbook contains a comprehensive collection of hundreds of questions and corresponding answer schemes, presented in worksheet format. The questions are carefully arranged according to their respective chapters and topics, which align with the latest IGCSE or AS/A Level subject content. Here are the key features of these resources:

1. The workbook covers a wide range of topics, which are organized according to the latest syllabus content for Cambridge IGCSE or AS/A Level exams.
2. Each topic includes numerous questions, allowing students to practice and reinforce their understanding of key concepts and skills.
3. The questions are accompanied by detailed answer schemes, which provide clear explanations and guidance for students to improve their performance.
4. The workbook's format is user-friendly, with worksheets that are easy to read and navigate.
5. This workbook is an ideal resource for students who want to familiarize themselves with the types of questions that may appear in their exams and to develop their problem-solving and analytical skills.

Overall, Topical Past Paper Questions Workbooks are a valuable tool for students preparing for IGCSE or AS/A Level exams, providing them with the opportunity to practice and refine their knowledge and skills in a structured and comprehensive manner. To provide a clearer description of this book's specifications, here are some key details:

- Title: Cambridge AS & A Level Mathematics (9709) Paper 6 Topical Past Papers
- Subtitle: Exam Practice Worksheets With Answer Scheme
- Examination board: Cambridge Assessment International Education (CAIE)
- Subject code: 9709
- Years covered: February/March 2020 – October/November 2025
- Paper: 6 (Probability & Statistics 2)
- Number of pages: 741
- Number of questions: 296

Contents

Chapter 1

The Poisson distribution

1. 9709_s25_qp_61 Q: 1

It is known that 1% of houses in a certain area have a wind turbine. A random sample of 400 houses in this area is chosen for a survey on domestic heating. The number of houses in the sample that have a wind turbine is denoted by X.

Use a suitable approximating distribution to find $\mathrm{P}(X \leqslant 3)$. [3]

Answer:

Question	Answer	Marks	Guidance
	$(\lambda) = 4$	**B1**	SOI.
	$e^{-4}\left(1+4+\frac{4^2}{2!}+\frac{4^3}{3!}\right)=e^{-4}$ (1 + 4 + 8 + 10.6666) = 0.018316 + 0.073263 + 0.146525 + 0.19537	**M1**	Allow any λ, allow one end error.
	= 0.433	**A1**	**SC$_1$** Unsupported answer of 0.433 scores **B1B1**. **SC$_2$** Use of Normal mean = 4 **B1**. **SC$_3$** Use Binomial 0.432 or 0.433 scores **B1**.
		3	

2. 9709_w25_qp_62 Q: 4

An inspector believes that 18% of cups made at a certain factory contain flaws. The factory owner claims that the true percentage is less than 18%. The inspector examines a random sample of 40 cups and finds that 3 of them contain flaws.

(a) Stating a necessary assumption, use a binomial distribution to test the factory owner's claim at the 5% significance level. [6]

(b) Explain why it would **not** be appropriate to use the Poisson approximation to the binomial distribution to carry out the test in part **(a)**. [1]

Answer:

Question	Answer	Marks	Guidance
(a)	Assume flaws in cups are independent OR prob of containing a flaw is the same for all cups	**B1**	OE in context (e.g. prob… is consistent) but p = 0.18 is **B0**.
	H_0: P(contains flaw) = 0.18 H_1: P(contains flaw) < 0.18	**B1**	Both. Allow 'p'
	[P($X \leqslant 3$) =] $0.82^{40} + 40\times0.82^{39}\times0.18 + {}^{40}C_2\times0.82^{38}\times0.18^2 + {}^{40}C_3\times0.82^{37}\times0.18^3$ =0.0003569 + 0.0031338 + 0.013414 + 0.037298	**M1**	
	0.0542 (3 sf)	**A1**	Unsupported 0.0542 scores **M0B1**.
	0.0542>0.05	**M1**	Valid comparison – must be a tail probability Or if CR found ($\leqslant$2) then comparison with 3 **M1**.
	[Accept H_0] Insufficient evidence to accept factory owners claim. [Insufficient evidence that percentage less than 18%]	**A1FT**	In context, not definite, no contradictions no use of 'p' unless defined. e.g. not '%age is not less than 0.18' or '%age is 18%' 2TT scores max **B1B0M1A1M1**(with 0.025) is **A0**.
			Normal approx'n: (First **B1B1*** if earned) then: CV = $\frac{3.5-40\times0.18}{\sqrt{40\times0.18\times0.82)}}$ = ±1.523 **SCB1** (need cc). 1.523< 1.645 or 0.0639>0.05 No evidence less than 18% **SCB1**. *hypotheses μ=7.2 and μ<7.2 can score if Normal approx. used.
		6	

Question	Answer	Marks	Guidance
(b)	np = 7.2 which is too large, or > 5. Or n = 40 which is not greater than 50. Or p = 0.18 which is not small or > 0.1.	**B1**	Context required (7.2 or 40 or 0.18). One correct condition required ISW.
		1	

3. 9709_w25_qp_63 Q: 2

The mean mass of packets of Trueleaf tea is supposed to be 500 grams. An inspector wishes to test whether this value is correct. He weighs 60 randomly chosen packets and notes the mass, x grams, of each packet. The results are summarised as follows.

$$n = 60 \qquad \Sigma x = 29\,970 \qquad \Sigma x^2 = 14\,970\,300$$

Test, at the 5% significance level, whether the population mean mass is 500 grams. [8]

Answer:

Question	Answer	Marks	Guidance
	est (μ) = 499.5 or 29970/60	**B1**	
	est (σ^2) = $\frac{60}{59}\left(\frac{14970300}{60} - \text{'499.5'}^2\right)$ or $1/59(14970300 - (29970)^2/60)$	**M1**	Biased var = 4.75 **M0**.
	= 4.83 or 285/59	**A1**	
	H_0: Pop mean (or μ) = 500 H_1: Pop mean (or μ) ≠ 500	**B1**	Both. Not just 'mean'.
	$\frac{\text{'499.5'} - 500}{\frac{\sqrt{\text{'4.83'}}}{\sqrt{60}}}$	**M1**	For standardising with their values. Must have ÷√60 . Ignore cc s.
	= –1.762	**A1**	Allow −1.778 (from biased variance) accept 3 sf if nothing better.
	'1.762' < 1.96 or −'1.762' > −1.96 0.0390 > 0.025	**M1**	For valid comparison. Allow 1.778 < 1.96 0.0377 > 0.025.
	There is insufficient evidence that [mean] mass is not 500g	**A1FT**	In context. Not definite. No contradictions. **FT** from incorrect z. μ only accepted if defined. Accept CV method 499.5 > 499.44. Using biased var or using incorrect hypothesis can score a maximum of 6/8.
		8	

4. 9709_w24_qp_61 Q: 6

The numbers of customers arriving at service desks A and B during a 10-minute period have the independent distributions Po(1.8) and Po(2.1) respectively.

(a) Find the probability that during a randomly chosen 15-minute period more than 2 customers will arrive at desk A. [2]

(b) Find the probability that during a randomly chosen 5-minute period the total number of customers arriving at both desks is less than 4. [3]

(c) An inspector waits at desk *B*. She wants to wait long enough to be 90% certain of seeing at least one customer arrive at the desk.

Find the minimum time for which she should wait, giving your answer correct to the nearest minute. [4]

Answer:

Question	Answer	Marks	Guidance
(a)	[$\lambda = 2.7$] $1 - e^{-2.7}(1 + 2.7 + \frac{2.7^2}{2})$ or $1 - e^{-2.7}(1 + 2.7 + 3.645)$ or 1- (0.06721 + 0.1815 + 0.2450)	**M1**	Any λ. Allow one end error. Must see expression.
	= 0.506 (3 sf)	**A1**	SC unsupported answer 0.506 scores **B1**.
		2	

Question	Answer	Marks	Guidance
(b)	$\lambda = 1.95$	**B1**	
	$e^{-1.95}(1 + 1.95 + \frac{1.95^2}{2} + \frac{1.95^3}{3!})$ or $e^{-1.95}(1 + 1.95 + 1.90125 + 1.2358)$ or 0.1423 + 0.2774+ 0.2705 + 0.1758	**M1**	Any λ. Allow one end error. Must see expression.
	= 0.866	**A1**	SC unsupported answer 0.866 scores **B1B1**.
		3	
(c)	$1 - e^{-2.1x} \geqslant 0.90$ or $1 - e^{-\lambda} \geqslant 0.90$	**M1**	OE Condone use of '=' throughout.
	$[e^{-2.1x} \leq 0.1]$ or $e^{-\lambda} \leq 0.1$ $-2.1x \leq \ln 0.1$ or $-\lambda \leq \ln 0.1$ [$\lambda \geq 2.3026$, 2.3026/2.1]	**M1**	Rearrange and attempt take logs of relevant form.
	1.096 or 10.96 accept 1.097 or 10.97	***A1**	Seen.
	She must wait for at least 11 minutes	**A1 dep**	
			SC Use of trial and improvement. Use of $1-e^{-\lambda}$ any numerical λ (not 2.1) ie one trial **M1**. Use of enough trials to give an answer of 0.90 (2sf) **M1**. λ=2.30 i.e. 3sf accuracy AND 1.09… or 10.9 … **A1**. Then 11 **A1** dep.
		4	

5. 9709_w24_qp_62 Q: 3

A factory owner models the number of employees who use the factory canteen on any day by the distribution B(25, p). In the past the value of p was 0.8 . A new menu is introduced in the canteen and the owner wants to test whether the value of p has increased.

On a randomly chosen day he notes that the number of employees who use the canteen is 23.

(a) Use the binomial distribution to carry out the test at the 10% significance level. [5]

(b) Given that there are 30 employees at the factory comment on the suitability of the owner's model. [1]

Answer:

Question	Answer	Marks	Guidance
(a)	H_0: $p = 0.8$ H_1: $p > 0.8$	**B1**	
	[Assuming H_0, $P(X \geqslant 23)$ =] ${}^{25}C_{23}\times 0.2^2\times 0.8^{23} + {}^{25}C_{24}\times 0.2\times 0.8^{24} + 0.8^{25}$ =0.070835 + 0.0236118 + 0.0037779	**M1**	No end errors. Expression must be seen or supported by enough figures to be convinced B(25,0.8) used. Accept correct Σ notation.
	= 0.0982	**A1**	**SC B1** for 0.0982 unsupported.
	0.0982 < 0.1	**M1**	Valid comparison their 0.0982 must be a tail probability.
	[There is evidence to reject H_0] There is sufficient evidence to suggest that p has increased	**ftA1**	No contradictions. In context, non-definite. Condone 'there is sufficient evidence that the 'claim' is correct' and condone 'there is sufficient evidence that the number of employees (using the canteen) has increased' Note: CR method will include $P(X \geqslant 23)$ so **M1 A1** as above, and $P(X \geqslant 22)=0.234>0.1$ with at least one probability comparison with 0.1 needed to find CR of 23,24,25 (so 23 in CR) **M1 A1ft** as above.
		5	
(b)	Not suitable as model does not allow for more than 25 employees to use the canteen/Not suitable as uses a sample instead of all employees/Not suitable doesn't include all employees /Not suitable as 30 is only just bigger than 25 should have used 30 OR Suitable as owner knows that not all employees use the canteen, or similar	**B1**	Need both (i.e. suitable or not suitable plus reason).
		1	

6. 9709_s23_qp_61 Q: 6

A sample of 5 randomly selected values of a variable X is as follows:

$$1 \quad 2 \quad 6 \quad 1 \quad a$$

where $a > 0$.

Given that an unbiased estimate of the variance of X calculated from this sample is $\frac{11}{2}$, find the value of a. [3]

Answer:

Question	Answer	Marks	Guidance
	$\frac{5}{4}\left(\frac{1+2^2+6^2+1+a^2}{5}-\left(\frac{1+2+6+1+a}{5}\right)^2\right)=\frac{11}{2}$ or $\frac{1}{4}\left((42+a^2)-\frac{(10+a^2)}{5}\right)=\frac{11}{2}$	**M1***	OE attempted or e.g., $\frac{42+a^2}{5}-\left(\frac{10+a}{5}\right)^2=\frac{22}{5}$. Allow use of biased i.e., without $\frac{5}{4}$.
	$4a^2 - 20a + 0 = 0$ or $a^2 - 5a + 0 = 0$	**DM1**	Two- or three-term quadratic equation in a, with at least two terms correct.
	$a = 5$	**A1**	Ignore $a = 0$, if seen.
		3	

7. 9709_w23_qp_62 Q: 6

A factory makes loaves of bread in batches. One batch of loaves contains X kilograms of dried yeast and Y kilograms of flour, where X and Y have the independent distributions $N(0.7, 0.02^2)$ and $N(100.0, 3.0^2)$ respectively.

Dried yeast costs \$13.50 per kilogram and flour costs \$0.90 per kilogram. For making one batch of bread the total of all other costs is \$55. The factory sells each batch of bread for \$200.

Find the probability that the profit made on one randomly chosen batch of bread is greater than \$40. [7]

Answer:

Question	Answer	Marks	Guidance
	Cost of dried yeast and flour: $\$D$ and $\$F$ $E(D) = 13.5 \times 0.7 = 9.45$ $E(F) = 0.9 \times 100 = 90$	**B1**	One of these soi – can be given at early stage.
	$\text{Var}(D) = 0.02^2 \times 13.50^2 = 0.0729$ $\text{Var}(F) = 3.0^2 \times 0.90^2 = 7.29$	**B1**	One of these soi – can be given at early stage.
	Total cost: $T \sim N(99.45, (0.02^2 \times 13.50^2 + 3.0^2 \times 0.90^2))$	**M1**	Attempt to combine their D and their F with or without 55 and 200 (but variance must not include 55 or 200). Or $N(99.45 + 55, (0.02^2 \times 13.50^2 + 3.0^2 \times 0.90^2))$. Or $N(200 - 55 - 99.45, (0.02^2 \times 13.50^2 + 3.0^2 \times 0.90^2))$. Or $N(99.45 + c, (0.02^2 \times 13.50^2 + 3.0^2 \times 0.90^2))$.
	N(99.45, 7.3629) accept 99.4 or 99.5	**A1**	Or N(154.45,7.3629) or N(45.55, 7.3629). Accept 3sf (accept 45.5 or 45.6).
	[P(profit > \$40) = P(T < 105)] $\frac{105 - '99.45'}{\sqrt{'7.3629'}}$ [= 2.045]	**M1**	$160 - 154.45/\sqrt{7.3629}$ or $40 - 45.55/\sqrt{7.3629}$. No mixed methods.
	[P(T < 105) = P(z < 2.045) =] $\phi(2.045)$	**M1**	For area consistent with their working.
	= 0.9795 or 0.9796 or 0.98(0) or 0.979 (3 sf)	**A1**	
		7	

8. 9709_w23_qp_63 Q: 3

A website owner finds that, on average, his website receives 0.3 hits per minute. He believes that the number of hits per minute follows a Poisson distribution.

(a) Assume that the owner is correct.

(i) Find the probability that there will be at least 4 hits during a 10-minute period. [3]

(ii) Use a suitable approximating distribution to find the probability that there will be fewer than 40 hits during a 3-hour period. [4]

A friend agrees that the website receives, on average, 0.3 hits per minute. However, she notices that the number of hits during the day-time (9.00 am to 9.00 pm) is usually about twice the number of hits during the night-time (9.00 pm to 9.00 am).

(b) **(i)** Explain why this fact contradicts the owner's belief that the number of hits per minute follows a Poisson distribution. [1]

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(ii) Specify separate Poisson distributions that might be suitable models for the number of hits during the day-time and during the night-time. [2]

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Answer:

Question	Answer	Marks	Guidance
(a)(i)	$\lambda = 3$	**B1**	For mean = 3.
	$1 - e^{-3}(1 + 3 + \frac{3^2}{2} + \frac{3^3}{3!})$ or $1 - e^{-3}(1 + 3 + 4.5 + 4.5)$ or $1 - (0.04979 + 0.14936 + 0.22404 + 0.22404)$	**M1**	Any λ. Allow one end error.
	= 0.353 (3 sf)	**A1**	No working scores B1.
		3	
(a)(ii)	N(54, 54)	**M1**	soi
	$\frac{39.5 - 54}{\sqrt{54}}$ (= –1.973)	**M1**	Allow with wrong or no continuity correction. For standardising with their mean and variance.
	$1 - \Phi$ ('1.973')	**M1**	For area consistent with their working.
	= 0.0242 (3 sf)	**A1**	Special case: if no working seen, 0.0242 scores **SC B3**, 0.0284 scores **SC B2**.
		4	
(b)(i)	'Mean not constant' or' 'number of hits per minute not constant' or 'not a constant rate'	**B1**	
		1	
(b)(ii)	$2p + p = 2 \times 0.3$ [$\Rightarrow p = 0.2$] [where p is the rate per minute for night time]	**M1**	May be implied by answer.
	[During day-time]: Po(0.4). [During night-time]: Po(0.2)	**A1**	Accept Po(24) [per daytime hour], Po(12) [per night time hour]. Accept Po(288) [per day time shift], Po(144)[per night time shift]. Note: Po(432), Po(216) scores M0A0.
		2	

9. 9709_m22_qp_62 Q: 7

(a) Two ponds, A and B, each contain a large number of fish. It is known that 2.4% of fish in pond A are carp and 1.8% of fish in pond B are carp. Random samples of 50 fish from pond A and 60 fish from pond B are selected.

Use appropriate Poisson approximations to find the following probabilities.

(i) The samples contain at least 2 carp from pond A and at least 2 carp from pond B. [3]

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(ii) The samples contain at least 4 carp altogether. [3]

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(b) The random variables X and Y have the distributions $\text{Po}(\lambda)$ and $\text{Po}(\mu)$ respectively. It is given that

- $\text{P}(X = 0) = [\text{P}(Y = 0)]^2$,
- $\text{P}(X = 2) = k[\text{P}(Y = 1)]^2$, where k is a non-zero constant.

Find the value of k. [4]

Answer:

Question	Answer	Marks	Guidance
(a)(i)	0.024×50 [= 1.2] and 0.018×60 [= 1.08]	**B1**	
	$(1 - e^{-1.2}(1 + 1.2)) \times (1 - e^{-1.08}(1 + 1.08))$	**M1**	For $(1 - e^{-\lambda}(1+\lambda)) \times (1 - e^{-\mu}(1+\mu))$ any λ, μ ($\lambda \neq \mu$) Allow one end error on either or both terms
	= 0.0991 (3 sf)	**A1**	Unsupported answer scores maximum **SC** B1 B1 **SC** Use of binomial 0.0994 scores B1 only
		3	
(a)(ii)	$\lambda = 0.024 \times 50 + 0.018 \times 60$	**M1**	or *their* 1.2 + 1.08 (NB 0.024+0.018 is M0)
	$1 - e^{-2.28} \times \left(1 + 2.28 + \frac{2.28^2}{2!} + \frac{2.28^3}{3!}\right)$	**M1**	any λ and allow one end error
	= 0.197 (3 sf)	**A1**	Unsupported answer scores maximum **SC** B2
		3	
(b)	$e^{-\lambda} = \left[e^{-\mu}\right]^2 = e^{-2\mu}$	**M1**	
	$e^{-\lambda} \times \frac{\lambda^2}{2} = k\left[e^{-\mu} \times \mu\right]^2$	**M1**	
	$e^{-2\mu} \times 2\mu^2 = k \times e^{-2\mu} \times \mu^2$	**M1**	OE. Use of $\lambda = 2\mu$ to find equation in μ and k only (or λ and k only)
	$k = 2$	**A1**	
		4	

10. 9709_s22_qp_61 Q: 5

Cars arrive at a fuel station at random and at a constant average rate of 13.5 per hour.

(a) Find the probability that more than 4 cars arrive during a 20-minute period. [3]

(b) Use an approximating distribution to find the probability that the number of cars that arrive during a 12-hour period is between 150 and 160 inclusive. [4]

Independently of cars, trucks arrive at the fuel station at random and at a constant average rate of 3.6 per 15-minute period.

(c) Find the probability that the total number of cars and trucks arriving at the fuel station during a 10-minute period is more than 3 and less than 7. [3]

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Answer:

Question	Answer	Marks	Guidance
(a)	$\lambda = 4.5$	**B1**	
	$1 - e^{-4.5}(1 + 4.5 + \frac{4.5^2}{2!} + \frac{4.5^3}{3!} + \frac{4.5^4}{4!})$	**M1**	Allow one end error Allow any λ. Poisson expressions must be seen
	= 0.468 (3 sf)	**A1**	If M0 awarded allow SC B1 for 0.468
		3	
(b)	$\lambda = 162$ $(X \sim \text{Po}(162) \Rightarrow X \sim \text{N}(162, 162))$	**B1**	
	$\frac{149.5 - \text{'162'}}{\sqrt{\text{'162'}}}$ and $\frac{160.5 - \text{'162'}}{\sqrt{\text{'162'}}}$ (= –0.982 and –0.118)	**M1**	One of these; allow with incorrect or no continuity correction
	Φ('0.982') – ϕ('0.118') oe	**M1**	Area consistent with *their* values (both standardisations must be seen)
	= 0.290 (3 sf)	**A1**	Allow 0.29
		4	

Question	Answer	Marks	Guidance
(c)	$\lambda = \frac{13.5}{6} + 3.6 \times \frac{2}{3}$ OE or 4.65	**M1**	Attempt to find λ
	$e^{-4.65}(\frac{4.65^4}{4!} + \frac{4.65^5}{5!} + \frac{4.65^6}{6!})$	**M1**	Allow any λ Allow one end error Poisson terms not be seen
	0.494 (3 sf)	**A1**	If M0 allow SC B1 for 0.494
		3	

11. 9709_s22_qp_62 Q: 3

It is known that 1.8% of children in a certain country have not been vaccinated against measles. A random sample of 200 children in this country is chosen.

(a) Use a suitable approximating distribution to find the probability that there are fewer than 3 children in the sample who have not been vaccinated against measles. [4]

(b) Justify your approximating distribution. [2]

Answer:

Question	Answer	Marks	Guidance
(a)	Poisson	**B1**	SOI
	Mean = 3.6	**B1**	Can be awarded for N(3.6, …)
	$e^{-3.6}(1 + 3.6 + \frac{3.6^2}{2})$	**M1**	Allow any λ Allow one end error Expression must be seen
	0.303 (3 s.f.)	**A1**	If M0 awarded allow SC B1 for 0.303 SC Use of binomial: B1 for answer 0.300 (3 sf)
		4	
(b)	[Binomial with] 200 > 50	**B1**	
	[200 × 0.018 =] 3.6 < 5 or [p =] 0.018 < 0.1	**B1**	If B0 B0 then SC n large, p small: B1 or n large $np < 5$: B1 or $n > 50$ and either $np < 5$ or $p < 0.1$: B1
		2	

12. 9709_s22_qp_62 Q: 7

X is a random variable with distribution Po(2.90). A random sample of 100 values of X is taken.

Find the probability that the sample mean is less than 2.88. [5]

Answer:

Question	Answer	Marks	Guidance
	$\bar{X} \sim N(2.9, \frac{2.9}{100})$ OR Totals method N(290, 290)	**B1**	B1 for N(2.9, …) OR N(290, …)
		B1	B1 for Var = $\frac{2.9}{100}$ OR for var = 290 SOI
	$\frac{2.88-2.90}{\sqrt{\frac{2.9}{100}}}$ [= –0.1174] OR $\frac{288-290}{\sqrt{290}}$	**M1**	Standardising with *their* values Allow without –ve sign AND/OR with incorrect continuity correction No mixed methods
	1– Φ('0.1174')	**M1**	For area consistent with *their* values
	0.453 (3 sf)	**A1**	As final answer
	Alternative method for question 7		
	$\bar{X} \sim N(2.9, \frac{2.9}{100})$ OR Totals method N(290, 290)	**B1**	B1 for N(2.9, …) OR N(290, …)
		B1	B1 for Var = $\frac{2.9}{100}$ OR Var = 290 stated or implied
	$\frac{(2.88-\frac{1}{200})-2.90}{\sqrt{\frac{2.9}{100}}}$ [= –0.1468] OR (287.5 – 290)/√290	**M1**	Standardising with *their* values Allow without –ve sign AND/OR with incorrect continuity correction No mixed methods
	1 – ϕ('0.1468')	**M1**	For area consistent with *their* values
	0.442 (3 sf)	**A1**	As final answer
		5	