



Mark Scheme (Results)

Summer 2018

Pearson Edexcel GCE A Level Mathematics
Statistics & Mechanics (9MA0/03)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the last candidate in exactly the same way as they mark the first.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification/indicative content will not be exhaustive.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, a senior examiner must be consulted before a mark is awarded.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 100.
2. These mark schemes use the following types of marks:
 - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
 - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
 - **B** marks are unconditional accuracy marks (independent of M marks)
 - Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- **bod** – benefit of doubt
- **ft** – follow through
- the symbol \surd will be used for correct ft
- **cao** – correct answer only
- **cs0** - correct solution only. There must be no errors in this part of the question to obtain this mark
- **isw** – ignore subsequent working
- **awrt** – answers which round to
- **SC**: special case
- **o.e.** – or equivalent (and appropriate)
- **d** or **dep** – dependent
- **indep** – independent
- **dp** decimal places
- **sf** significant figures
- * The answer is printed on the paper or ag- answer given

4. All M marks are follow through.

A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but answers that don't logically make sense e.g. if an answer given for a probability is >1 or <0 , should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. Where a candidate has made multiple responses and indicates which response they wish to submit, examiners should mark this response.
If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

7. Ignore wrong working or incorrect statements following a correct answer.

8. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used. If no such alternative answer is provided but the response is deemed to be valid, examiners must escalate the response for a senior examiner to review.

Section A: STATISTICS

Qu 1	Scheme	Marks	AO																				
(a)	<table border="1" style="margin: auto; border-collapse: collapse;"> <tr> <td style="padding: 2px;">c</td> <td style="padding: 2px;">0</td> <td style="padding: 2px;">1</td> <td style="padding: 2px;">2</td> <td style="padding: 2px;">3</td> <td style="padding: 2px;">4</td> <td style="padding: 2px;">5</td> <td style="padding: 2px;">6</td> <td style="padding: 2px;">7</td> <td style="padding: 2px;">8</td> </tr> <tr> <td style="padding: 2px;">$P(C = c)$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> <td style="padding: 2px;">$\frac{1}{9}$</td> </tr> </table>	c	0	1	2	3	4	5	6	7	8	$P(C = c)$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	B1	1.2
	c	0	1	2	3	4	5	6	7	8													
	$P(C = c)$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$													
			B1ft	1.2																			
		(2)																					
(b)	$P(C < 4) = \frac{4}{9}$ (accept 0.444 or better)	B1	3.4																				
(c)	Probability lower than expected suggests model is <u>not</u> good	B1ft	3.5a																				
(d)	e.g. Cloud cover will vary from month to month and place to place So e.g. use a non-uniform distribution	B1	3.5c																				
		(5 marks)																					
Notes																							
(a)	<p>1st B1 for a correct set of values for c. Allow $\{\frac{1}{8}, \frac{2}{8}, \dots, \frac{8}{8}\}$</p> <p>2nd B1ft for correct probs from their values for c, consistent with discrete uniform distrib'n Maybe as a prob. function. Allow $P(X = x) = \frac{1}{9}$ for $0 \leq x \leq 8$ provided $x = \{0, 1, 2, \dots, 8\}$ is clearly defined somewhere.</p>																						
(b)	B1 for using correct model to get $\frac{4}{9}$ (o.e.)																						
SC	Sample space {1, ..., 8} If scored B0B1 in (a) for this allow $P(C < 4) = \frac{3}{8}$ to score B1 in (b)																						
(c)	<p>B1ft for comment that states that the model proposed is or is not a good one based on their model in part (a) and their probability in (b)</p> <p> (b) – 0.315 > 0.05 Allow e.g. “it is not suitable”; “it is not accurate” etc</p> <p> (b) – 0.315 ≤ 0.05 Allow a comment that suggests it <u>is</u> suitable</p> <p>No prob in (b) Allow a comparison that mentions 50% or 0.5 and rejects the model</p> <p>No prob in (b) and no 50% or 0.5 or (b) > 1 scores B0</p> <p style="padding-left: 20px;">Ignore any comments about location or weather patterns.</p>																						
(d)	<p>B1 for a sensible refinement considering variations in month or location Just saying “not uniform” is B0</p> <p>Context & “non-uniform” Allow mention of different locations, months <u>and</u> non-uniform <u>or</u> use more locations to form a new distribution with probabilities based on frequencies</p> <p>Context & “binomial” Allow mention of different locations, months <u>and</u> binomial</p> <p>Just refined model Model must be outlined and discrete and non-uniform e.g. higher probabilities for more cloud cover <u>or</u> lower probabilities for less cloud cover</p> <p>Continuous model Any model that is based on a continuous distribution. e.g. normal is B0</p>																						

Qu 2	Scheme	Marks	AO
(a)	$H_0 : \rho = 0$ $H_1 : \rho < 0$ Critical value: -0.6215 (Allow any cv in range $0.5 < cv < 0.75$) $r < -0.6215$ so significant result and there is evidence of a negative correlation between w and t	B1 M1 A1 (3)	2.5 1.1a 2.2b
(b)	e.g. As temperature increases people spend more time on the beach and less time shopping (o.e.)	B1 (1)	2.4
(c)	Since r is close to -1 , it is consistent with the suggestion	B1 (1)	2.4
(d)	t will be the explanatory variable since sales are likely to depend on the temperature	B1 (1)	2.4
(e)	Every degree rise in temperature leads to a drop in weekly earnings of £171	B1 (1)	3.4
		(7 marks)	
Notes			
(a)	B1 for both hypotheses in terms of ρ M1 for the critical value: sight of ± 0.6215 or any cv such that $0.5 < cv < 0.75$ A1 must reject H_0 on basis of comparing -0.915 with -0.6215 (if $-0.915 < 0.6215$ is seen then A0 but may use $ r $ o.e. which is fine) <u>and</u> mention “negative”, “correlation/relationship” and at least “ w ” and “ t ”		
(b)	B1 for a suitable <u>reason to explain</u> negative correlation using the context given. e.g. “As temperature drops people are more likely to go shopping (than to the beach)” e.g. “As temperature increases people will be outside rather than in shops” A mere description in context of negative correlation is B0 SO e.g. “As temperature increases people don’t want to go shopping/buy clothes” is B0 e.g. “Less clothes needed as temp increases” is B0		
(c)	B1 for a suitable reason e.g. “strong”/”significant”/”near perfect” “correlation”, $ r $ close to 1 <u>and</u> saying it is consistent with the suggestion. Allow “yes” followed by the reason.		
(d)	B1 For identifying t <u>and</u> giving a suitable reason. Need idea that “ w <u>depends</u> on t ” or “ w <u>responds</u> to t ” or “ t <u>affects</u> w ” (o.e.) Allow t (temperature) <u>affects</u> the other variable etc Just saying “ t is the independent variable” or “ t <u>explains</u> change in w ” is B0 N. B. Suggesting causation is B0 e.g. “ t causes w to decrease”		
(e)	B1 for a description that conveys the idea of rate per degree Celsius. Must have 171, condone missing “£” sign.		

Qu 3	Scheme	Marks	AO										
(a)	The <u>probability</u> of a dart hitting the target is <u>constant</u> (from child to child and for each throw by each child) (o.e.)	B1	1.2										
	The <u>throws</u> of each of the darts are <u>independent</u> (o.e.)	B1	1.2										
(b)	$[P(H \geq 4) = 1 - P(H \leq 3) = 1 - 0.9872 = 0.012795.. =]$ awrt <u>0.0128</u>	B1 (2)	1.1b										
(c)	$P(F = 5) = 0.9^4 \times 0.1, = 0.06561$ = awrt <u>0.0656</u>	M1, A1 (2)	3.4 1.1b										
(d)	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>n</td> <td>1</td> <td>2</td> <td>...</td> <td>10</td> </tr> <tr> <td>$P(F = n)$</td> <td>0.01</td> <td>$0.01 + \alpha$</td> <td>...</td> <td>$0.01 + 9\alpha$</td> </tr> </table>	n	1	2	...	10	$P(F = n)$	0.01	$0.01 + \alpha$...	$0.01 + 9\alpha$	M1	3.1b
	n	1	2	...	10								
$P(F = n)$	0.01	$0.01 + \alpha$...	$0.01 + 9\alpha$									
	Sum of probs = 1 $\Rightarrow \frac{10}{2}[2 \times 0.01 + 9\alpha] = 1$ [i.e. $5(0.02 + 9\alpha) = 1$ or $0.1 + 45\alpha = 1$] so $\alpha = \mathbf{0.02}$	M1A1 A1 (4)	3.1a 1.1b 1.1b										
(e)	$P(F = 5 \text{Thomas' model}) = \mathbf{0.09}$	B1ft (1)	3.4										
(f)	<u>Peta's</u> model assumes the <u>probability</u> of hitting target is <u>constant</u> (o.e.) and <u>Thomas'</u> model assumes this <u>probability increases</u> with each attempt(o.e.)	B1 (1)	3.5a										
		(11 marks)											
Notes													
(a)	1 st B1 for stating that the <u>probability</u> (or possibility or chance) is <u>constant</u> (or fixed or same) 2 nd B1 for stating that <u>throws</u> are <u>independent</u> ["trials" are independent is B0]												
(b)	B1 for awrt 0.0128 (found on calculator)												
(c)	M1 for a probability expression of the form $(1-p)^4 \times p$ where $0 < p < 1$ A1 for awrt 0.0656 SC Allow M1A0 for answer only of 0.066												
(d)	1 st M1 for setting up the distribution of F with at least 3 correct values of n and $P(F = n)$ in terms of α . (Can be implied by 2 nd M1 or 1 st A1) 2 nd M1 for use of sum of probs = 1 and clear summation or use of arithmetic series formula (allow 1 error or missing term). (Can be implied by 1 st A1) 1 st A1 for a correct equation for α 2 nd A1 for $\alpha = 0.02$ (must be exact and come from correct working)												
(e)	B1ft for value resulting from $0.01 + 4 \times$ "their α " (provided α and the answer are probs) Beware If their answer is the same as their (c) (or a rounded version of their (c)) score B0												
(f)	B1 for a suitable comment about the <u>probability</u> of hitting the target ALT Allow idea that Peta's model suggests the dart may never hit the target but Thomas' says that it will hit at least once (in the first 10 throws).												

Qu 4	Scheme	Marks	AO
(a)	Convenience <u>or</u> opportunity [sampling]	B1 (1)	1.2
(b)	Quota [sampling] e.g. Take 4 people every 10 minutes	B1 B1 (2)	1.1a 1.1b
(c)	Census	B1 (1)	1.2
(d)	[58 – 26 =] 32 (min)	B1 (1)	1.1b
(e)	$\mu = \frac{4133}{95} = 43.505263\dots$ $\sigma_x = \sqrt{\frac{202\,294}{95} - \mu^2} = \sqrt{236.7026\dots}$ $= 15.385\dots$	awrt 43.5 (min) awrt 15.4 (min)	1.1b 1.1b 1.1b
(f)	There are outliers in the data (or data is skew) which will affect mean and sd Therefore use median and IQR	B1 dB1 (2)	2.4 2.4
(g)	Value of 20, LQ at 26 and outliers will not change <u>or</u> state that median and upper quartile are the values that <u>do</u> change <u>More values now below 40 than above so Q_2 or Q_3 will change and be lower</u> <u>Both Q_2 and Q_3 will be lower</u>	B1 M1 A1 (3)	1.1b 2.1 2.4
		(13 marks)	
Notes			
(b)	1 st B1 for quota (sampling) mentioned (“Stratified” or “systematic” or “random” are B0B0) 2 nd B1 for a description of how such a system might work, requires suitable strata or categories e.g. time slots, departments, gender, age groups, distance travelled etc Suggestion of randomness is B0		
(e)	B1 for a correct mean (awrt 43.5) M1 for a correct expression for the sd (including $\sqrt{\quad}$)ft their mean A1 for awrt 15.4 (Allow $s = 15.4667\dots$ awrt 15.5)		
(f)	1 st B1 for acknowledging <u>outliers</u> or <u>skewness</u> are a problem for <u>mean and sd</u> “extreme values”/“anomalies” OK May be implied by saying median and IQR not affected by.. We need to see mention of “outliers”, “skewness” and the problem so “data is skewed so use median and IQR” is B0 unless mention that they are not affected by extreme values <u>or</u> mean and standard deviation can be “inflated” by the positive skew etc 2 nd dB1 dep on 1 st B1 for therefore choosing <u>median and IQR</u>		
(g)	B1 for identifying 2 of these 3 groups of unchanged values or stating only Q_2 and Q_3 change M1 for <u>explaining</u> that median or UQ should be lower. E.g. the 2 values have moved to below 40 (or 58) and therefore more than 50% below 40 or (more than 75% below 58) <u>or</u> an argument to show that the other 3 values are the same. (o.e.) Allow arrows on box plot provided statement in words about increased % below 40 or 58 etc A1 for stating median <u>and</u> UQ are both lower with clear evidence of M1 scored [If lots of values on 40 then median might not change but, since two values <u>do</u> change then UQ would change. If this meant that 92 became an outlier then we would have a new value for upper whisker and an extra outlier so effectively 3 values are altered. So median changes]		

Qu 5	Scheme	Marks	AO
(a)	$P(L > 16) = 0.69146\dots$	awrt 0.691	B1 (1) 1.1b
(b)	$P(L > 20 L > 16) = \frac{P(L > 20)}{P(L > 16)}$ $= \frac{0.308537\dots}{(a)} \text{ or } \frac{1-(a)}{(a)}, = 0.44621\dots$ <p>For calc to work require $(0.44621\dots)^4 = 0.03964\dots$</p>	awrt 0.0396	M1 3.1b A1ft, A1 1.1b dM1 2.1 A1 1.1b (5)
(c)	<p>Require: $[P(L > 4)]^2 \times [P(L > 20 L > 16)]^2$</p> $= (0.99976\dots)^2 \times (0.44621\dots)^2$ $= 0.19901\dots$	awrt 0.199 (*)	M1 1.1a A1ft 1.1b A1cso* 1.1b (3)
(d)	$H_0 : \mu = 18 \quad H_1 : \mu > 18$ $\bar{L} \sim N\left(18, \left(\frac{4}{\sqrt{20}}\right)^2\right)$ $P(\bar{L} > 19.2) = P(Z > 1.3416\dots) = 0.089856\dots$ <p>(0.0899 > 5%) <u>or</u> (19.2 < 19.5) <u>or</u> 1.34 < 1.6449 so not significant Insufficient evidence to support Alice's claim (or belief)</p>		B1 2.5 M1 3.3 A1 3.4 A1 1.1b A1 3.5a (5)
Notes			
(a)	B1 for evaluating probability using their calculator (awrt 0.691) Accept 0.6915		
(b)	1 st M1 for a first step of identifying a suitable conditional probability (either form) 1 st A1ft for a ratio of probabilities with numerator = awrt 0.309 or 1 – (a) and denom = their (a) 2 nd A1 for awrt 0.446 (o.e.) Accept 0.4465 (from $\frac{0.3085}{0.691} = 0.44645\dots$) NB $\frac{P(16 < L < 20)}{P(L > 16)} = 0.5538\dots$ scores M1A1A1 when they do $1 - 0.5538 = 0.4462\dots$ 2 nd M1 (dep on 1 st M1) for 2 nd correct step i.e. (their 0.446...) ⁴ <u>or</u> $X \sim B(4, "0.446")$ and $P(X = 4)$ 3 rd A1 for awrt 0.0396		
(c)	1 st M1 for a correct approach to solving the problem (May be implied by A1ft) 1 st A1ft for $P(L > 4) =$ awrt 0.9998 used <u>and</u> ft their 0.44621 in correct expression If use $P(L > 20) = 0.3085\dots$ as 0.446.. in (b) then M1 for $(0.3085\dots)^2 \times [P(L > 4)]^2$; A1ft as above * 2 nd A1cso for 0.199 or better with clear evidence of M1 [NB $(0.4662\dots)^2 = 0.199\dots$ is M0A0A0] Must see M1 scored by correct expression in symbols or values (M1A1ft)		
(d)	B1 for both hypotheses in terms of μ . M1 for selecting a suitable model. Sight of <u>normal</u> , <u>mean</u> 18, <u>sd</u> $\frac{4}{\sqrt{20}}$ (o.e.) or <u>variance</u> = 0.8 1 st A1 for using the model correctly. Allow awrt 0.0899 <u>or</u> 0.09 from correct prob. statement CR $(\bar{L}) > 19.471\dots$ (accept awrt 19.5) <u>or</u> CV of 1.6449 (or better: calc 1.6448536..)		
ALT	2 nd A1 for correct non-contextual conclusion. Wrong comparison or contradictions A0 Error giving 2 nd A0 implies 3 rd A0 but just a correct contextual conclusion can score A1A1 3 rd A1 dep on M1 and 1 st A1 for a correct contextual conclusion mentioning <u>Alice's claim</u> / <u>belief</u> <u>or</u> there is insufficient evidence that the mean <u>lifetime</u> is more than 18 hours		