

Mark Scheme (Results)

November 2021

Pearson Edexcel GCE

In Mathematics (9MA0)

Paper 31 Statistics

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

October 2021
Question Paper Log Number P68828A
Publications Code 9MA0_03_2111_MS
All the material in this publication is copyright
© Pearson Education Ltd 2021

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- 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.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- 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 may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 100.

2. The Edexcel Mathematics 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
- cso - 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
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper

- ⌐ The second mark is dependent on gaining the first mark

4. 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.

5. 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.

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

7. 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.

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom

9MA0-31 Mark Scheme October 2021(Final)

Qu 1	Scheme	Marks	AO
(a)	**Disadvantage:** e.g. Not random; cannot use (reliably) for inferences	B1 **(1)**	1.1b
(b)	[Sight or correct use of] $X \sim B(36, 0.08)$	M1	3.3
(i)	$P(X = 4) = 0.167387\ldots$ awrt **0.167**	A1	1.1b
(ii)	$[P(X \ldots 7) = 1 - P(X \text{„} 6) =]$ 0.022233… awrt **0.0222**	A1 **(3)**	1.1b
(c)	P(In dance club and dance tango) = 0.4×0.08 = **0.032** or $\frac{4}{125}$ or **3.2%**	B1 **(1)**	1.1b
(d)	[Let T = those who can dance the Tango. Sight or use of] $T \sim B(50, \text{“}0.032\text{”})$	M1	3.3
	$[P(T < 3) = P(T \text{„} 2) =]$ 0.7850815… awrt **0.785**	A1 **(2)**	1.1b
		(7 marks)	

Notes

(a) B1 for a suitable disadvantage:

Allow (B1)	Do NOT allow (B0)
Not random or less random (o.e.)	Not representative
Cannot use (reliably) for inferences	Less accurate
(More likely to be) biased	Any comment based on time or cost
	Any mention of skew
	Any mention of non-response

(b) M1 for sight of B(36, 0.08) Allow in words: binomial with $n = 36$ and $p = 0.08$
may be implied by one correct answer to 2sf or sight of $P(X \text{„} 6) = 0.97776...$ i.e. awrt 0.98
Allow for $36C4 \times 0.08^4 \times 0.92^{32}$ as this is "correct use"

(i) 1st A1 for awrt 0.167 NB An answer of just awrt 0.167 scores M1($\Rightarrow$)1st A1

(ii) 2nd A1 for awrt 0.0222

(c) B1 for 0.032 o.e. (Can allow for sight of 0.4×0.08)

(d) M1 for sight of B(50, “0.032”) ft their answer to (c) provided it is a probability $\neq 0.08$
may be implied by correct answer
or sight of $[P(T \text{„} 3)] = 0.924348\ldots$ i.e. awrt 0.924 or $P(T \text{„} 2)$ as part of $1 - P(T \text{„} 2)$ calc.
A1 for awrt 0.785

MR Allow MR of 50 (e.g. 30) provided clearly attempting $P(T \text{„} 2)$ and score M1A0

Qu 2	Scheme	Marks	AO
(a)	Negative	B1 **(1)**	1.2
(b)	Marc's suggestion <u>is compatible</u> because it's <u>negative correlation</u>	B1 **(1)**	2.4
(c)	$(r =)$ – 0.54458266… awrt **<u>– 0.545</u>**	B1 **(1)**	1.1b
(d)	$H_0 : \rho = 0$ $H_1 : \rho < 0$	B1	2.5
	[5% 1-tail cv =] (<u>+</u>) 0.4259	M1	1.1a
	(significant result / reject H_0) There <u>is</u> evidence of negative <u>correlation</u> between the <u>number of letters</u> in (or <u>length</u> of) a student's last <u>name</u> and their first <u>name</u>	A1 **(3)**	2.2b
		(6 marks)	

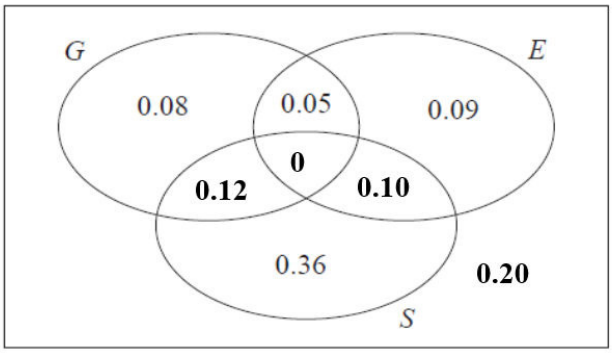
	Notes
(a)	B1 for "negative" Allow "slight" or "weak" etc Allow a description e.g. "as x increases y decreases" or in context e.g. "people with longer last names tend to have shorter first names" A comment of "negative skew" is B0 **Need to see distinct or separate responses for (a) and (b)**
(b)	B1 for a comment that suggests data is compatible with the suggestion **and** a suitable reason such as "there is negative correlation" <u>or</u> a description in x and y or in context <u>or</u> the points lie close to a line with <u>negative gradient</u> <u>or</u> draw line $y = x$ and state that <u>more points below the line</u> so <u>supports (or is compatible with)</u> his suggestion A reason based on just a **single point** is B0 e.g. " 11 letters in last name has only 5 in first name"
(c)	B1 for awrt – 0.545
(d)	B1 for both hypotheses correct in terms of ρ M1 for a critical value compatible with their H_1: 1-tail: awrt <u>+</u> 0.426 (condone <u>+</u> 0.425) **or** 2-tail (B0 scored for H_1) : awrt <u>+</u> 0.497 If hypotheses are in words and can deduce whether one or two-tail then use their words. If no hypotheses or their H_1 is not clearly one or two tail assume one-tail A1 for compatible signs between cv and r **and** a correct conclusion in context mentioning <u>correlation</u> and <u>number of letters</u> or <u>length</u> and <u>name</u> (ft their value from (c)) Do NOT award this A mark if contradictory comments or working seen e.g. "accept H_0" or comparison of 0.426 with significance level of 0.05 etc
NB	The M1A1 can be scored independently of the hypotheses

Qu 3	Scheme	Marks	AO
(a)	Hectopascal <u>or</u> hPa	B1 **(1)**	1.2
(b)	$\overline{x} = \overline{y} + 1010$ <u>or</u> $\frac{214}{30} + 1010$	M1	1.1b
	= 1017.1333… awrt **<u>1017</u>**	A1 **(2)**	1.1b
(c)	$\sigma_x = \sigma_y$ (or statement that standard deviation is not affected by this type of coding)	M1	3.1b
	$\left[\sigma_y =\right] \sqrt{\frac{5912}{30} - ("7.13[33...]")^2}$ <u>or</u> $\sqrt{146.1822...}$	M1	1.1b
	= 12.0905… awrt **<u>12.1</u>**	A1 **(3)**	1.1b
(d)	High pressure (since approx. mean + sd) so clockwise Locations are (from North to South): Leuchars, Heathrow, Hurn	B1	2.4
	Wind direction is direction wind blows <u>from</u> So: Heathrow (**NE**) Hurn (**E**) Leuchars (**W**)	B1 **(2)**	2.2a
		(8 marks)	

	Notes
FYI	1 hPa = 100 Pa; 10hPa = 1 kPa; 1Pa = 1 Nm^{-2}
(a)	B1 for "hectopascal" <u>or</u> hPa (condone pascals, allow millibars <u>or</u> mb) o.e. Do NOT allow kPa <u>or</u> kilopascals <u>or</u> Pa on its own
(b)	M1 for a strategy to find $\overline{x}$ Allow an attempt to find $\sum x$ that gets as far as $\sum x = \sum y + 30 \times 1010$ [= 30 514] A1 for awrt 1017 (accept 1020) [Ignore incorrect units]
(c)	1st M1 for an overall strategy using the fact $\sigma_x = \sigma_y$ (can be implied by correct <u>final</u> ans) <u>or</u> for $\sum x = 30\,514$ and $\sum x^2 = 31\,041\,192$ (both seen and correct) 2nd M1 for a correct expression (with $\sqrt{}$)(ft their $\overline{y}$ to 3sf) allow awrt 146 for 146.1822.. <u>or</u> for correct expression in x can ft their $\sum x > 30\,000$ or their answer to (b) A1 (dep on 2nd M1) for awrt 12.1 [Ignore incorrect units]
Final answer	Final ans of awrt 12.1 scores 3/3 **but** if they then adjust for x e.g. add 1010 (M0M1A1)
(d)	1st B1 for at least one of these reasons (these 2 lines) clearly stated (may see diagram) Need "high pressure" **and** "clockwise" to score on 1st line Contradictory statements B0 e.g. correct N~S list but say "anticlockwise" 2nd B1 (indep of 1st B1) for deducing the 3 correct directions either in the table or stated as above If the answers in table and text are different we take the table (as question says)

Qu 4	Scheme	Marks	AO
(a)	$0.08 + 0.09 + 0.36 = \underline{\mathbf{0.53}}$	B1	1.1b
		(1)	
(b)(i)	$\left[\mathrm{P}(G \cap E \cap S) = 0 \Rightarrow\right]$ $\underline{\boldsymbol{p = 0}}$	B1	1.1b
(ii)	$[\mathrm{P}(G) = 0.25 \Rightarrow]\ 0.08 + 0.05 + q + "p" = 0.25$	M1	1.1b
	$\underline{\boldsymbol{q = 0.12}}$	A1	1.1b
		(3)	
(c)(i)	$\left[\mathrm{P}(S \mid E) = \frac{5}{12} \Rightarrow\right] \frac{r + "p"}{r + "p" + 0.09 + 0.05} = \frac{5}{12}$	M1	3.1a
		A1ft	1.1b
	$[12r = 5r + 5 \times 0.14 \Rightarrow]$ $\underline{\boldsymbol{r = 0.10}}$	A1	1.1b
(ii)	$[0.08 + 0.05 + "0.12" + "0" + 0.09 + "0.10" + 0.36 + t = 1 \Rightarrow]$ $\underline{\boldsymbol{t = 0.20}}$	B1ft	1.1b
		(4)	
(d)	$\mathrm{P}(S \cap E') = 0.36 +$ "q" [= 0.48]	B1ft	1.1b
	$\mathrm{P}\left(\left[(S \cap E')\right] \cap G\right) =$ "q" [=0.12] **and** $\mathrm{P}(G) = 0.25$ **and**	M1	2.1
	$\mathrm{P}(S \cap E') \times \mathrm{P}(G) =$ "0.48" $\times \frac{1}{4}$ or 0.12		
	$\mathrm{P}(S \cap E') \times \mathrm{P}(G) = 0.12 = \mathrm{P}\left(\left[(S \cap E')\right] \cap G\right)$ so **are independent**	A1	2.2a
		(3)	
		(11 marks)	

	Notes
(a)	B1 for 0.53 (or exact equivalent) [Allow 53%]
(b)(i)	B1 for $p = 0$ (may be placed in Venn diagram)
(ii)	M1 for a linear equation for q (ft letter "p" or their value if $0 \leqslant p \leqslant 0.12$) $\Rightarrow$ by $p + q = 0.12$
	A1 for $q = 0.12$ (may be placed in Venn diagram)
(c)(i)	M1 for a ratio of probabilities (r on num and den) (on LHS) with num < den **and** num or den correct ft. Allow ft of letter "p" or their p where $0 \leqslant p < 0.86$ but "+ 0" is not required.
	1st A1ft for a correct ratio of probabilities (on LHS) allowing ft of their p where $0 \leqslant p < 0.86$
	2nd A1 for $r = 0.1(0)$ or exact equivalent (may be in Venn diagram) **Ans only** 3/3
(ii)	B1ft for $t = 0.2(0)$ (o.e.) or correct ft i.e. $0.42 - (p + q + r)$ where p, q, r and t are all probs
(d)	B1ft for $\mathrm{P}(S \cap E') = 0.48$ (with label) (ft letter "q" or their value if $0 \leqslant q \leqslant 0.12$)
	M1 for attempting all required probs (labelled) and using them in a correct test (allow ft of q)
	A1 for **all probs correct** and a correct deduction (no ft deduction here)
SC	**No "P"** If correct argument seen apart from P for probability for all 3 marks, award (B0M1A1)
	If unsure about an attempt using conditional probabilities, please send to review.



Qu 5	Scheme	Marks	AO
(a)	$\left[\text{Let } F \sim \text{N}\left(166.5, 6.1^2\right)\right]$ $\text{P}(F < k) = 0.01 \Rightarrow \dfrac{k-166.5}{6.1} = -2.3263$	M1	3.4
	$k = 152.309\ldots$ **152** or awrt **152.3**	A1	1.1b
		(2)	
(b)	[P($150 < F < 175$) =] 0.914840… awrt **0.915**	B1	1.1b
		(1)	
(c)	P($F > 160 \mid 150 < F < 175$)	M1	3.1b
	$= \dfrac{\text{P}(160 < F < 175)}{\text{P}(150 < F < 175)}$ or $\dfrac{\text{P}(160 < F < 175)}{\text{"(b)"}}$	M1	1.1b
	$= \dfrac{0.7749487...}{\text{"0.91484..."}}$	A1ft	1.1b
	= 0.84708… awrt **0.847**	A1	1.1b
		(4)	
(d)	$\text{H}_0 : \mu = 166.5$ $\text{H}_1 : \mu < 166.5$	B1	2.5
	[Let X = height of female from 2nd country] $\bar{X} \sim \text{N}\left(166.5, \left(\dfrac{7.4}{\sqrt{50}}\right)^2\right)$	M1	3.3
	$\text{P}\left(\bar{X} < 164.6\right) = 0.03472...$	A1	3.4
	[0.0347… < 0.05 so significant or reject H_0] There is evidence to support Mia's belief	dA1	2.2b
		(4)	
		(11 marks)	

	Notes
(a)	M1 for standardising (allow ±) with k, 166.5 and 6.1 and set equal to a z value $2.3 < \lvert z \rvert < 2.4$
	A1 for 152 or awrt 152.3 **Ans only** 2/2 [Condone poor use of notation e.g. $\text{P}(\frac{k-166.5}{6.1}) = -2.3263$]
	Allow percentages instead of probabilities throughout.
(b)	B1 for awrt 0.915
(c)	1st M1 for interpreting demand as an appropriate conditional probability ($\Rightarrow$ by 2nd M1)
	2nd M1 for correct ratio of expressions (can ft their (b) on denominator) ($\Rightarrow$ by 1st A1ft)
	1st A1ft for a correct ratio of probs (can ft their "0.9148…" to 3sf from (b) if > 0.775)
	2nd A1 for awrt 0.847
(d)	B1 for both correct hypotheses in terms of μ
	1st M1 for selecting the correct model (needn't use $\bar{X}$ $\Rightarrow$ by standardisation or 1st A1)
	1st A1 for correct use of the correct model i.e. awrt 0.035 (allow 0.04 if $\text{P}\left("\bar{X}" < 164.6\right)$ seen)
	Condone $\text{P}("\bar{X}" > 164.6) = 0.9652$ or awrt 0.97 only if comparison with 0.95 is made
ALT	**Use of *z* value:** Need to see $Z = -1.8(15\ldots)$ **and** cv of ± 1.6449 (allow 1.64 or better) for 1st A1
ALT	**Use of CR or CV for $\bar{X}$:** Need to see "$\bar{X}$"< 164.7786… or CV = … (awrt 164.8) for 1st A1
	Condone truncation i.e 164.7 or better
	2nd dA1 (**dep on M1A1** only) for a correct inference in context.
	Must mention Mia's belief **or** mean height of females/women
	Do NOT award if contradictory statements about hypotheses made e.g. "not sig"
SC	**M0 for** $\bar{X}$ ~N(**164.6**, …) If they achieve p = awrt 0.035 (o.e. with z-value or CV of 166.3) **and** a correct conclusion in context is given score M0A0A1 [and SC for awrt 0.97 > 0.95 case]

Qu 6	Scheme	Marks	AO
(a)	[Sum of probs = 1 implies] $\log_{36} a + \log_{36} b + \log_{36} c = 1$	M1	3.1a
	$\Rightarrow \log_{36}(abc) = 1$ so $abc = 36$	A1	3.4
	All probabilities greater than 0 implies each of a, b and $c > 1$	B1	2.2a
	$36 = 2^2 \times 3^2$ (or 3 numbers that multiply to give 36 e.g. 2, 2, 9 etc)	dM1	2.1
	Since a, b and c are distinct must be **2, 3, 6** **($a = 2$, $b = 3$, $c = 6$)**	A1 **(5)**	3.2a
(b)	$(\log_{36} a)^2 + (\log_{36} b)^2 + (\log_{36} c)^2$	M1	3.4
	[= 0.0374137…+ 0.09398737…+0.25]		
	= 0.38140… awrt **0.381**	A1 **(2)**	1.1b
		(7 marks)	

	Notes
(a)	1st M1 for a start to the problem using sum of probabilities leading to eq'n in a, b and c
	1st A1 for reducing to the equation $abc = 36$ [Must follow from their equation.]
NB	Can go straight from $abc = 36$ to the answer for full marks for part (a).
	B1 for deducing that each value > 1 (may be implied by 3 integers all > 1 in the next line)
	2nd dM1 (dep on M1A1) for writing 36 as a product of prime factors or 3 values with product = 36 and none = 1
	2nd A1 for 2, 3 and 6 as a list or $a = 2$, $b = 3$ and $c = 6$
SC	**M0M0** If no method marks scored but a correct answer given score: M0A0B1M0A1 (2/5)
Ans only	This gets the SC score of 2/5 [Question says show your working clearly]
(b)	M1 for a correct expression in terms of a, b and c or values; ft their integers a, b and c Condone invisible brackets if the answer implies they are used.
	A1 for awrt 0.381

G.B. Attwood 26/10/2021