Pearson Edexcel

Mark Scheme (Results)

October 2020

Pearson Edexcel GCE Advanced Level
In Mathematics (9MA0)
Paper 31 Statistics

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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 50.

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
   - **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
   - **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.

Qu 1	Scheme	Marks	AO
(a)	A, C or D, B or D,C	B1 **(1)**	1.2
(b)	[$p = 0.4 - 0.07 - 0.24$ =] **0.09**	B1 **(1)**	1.1b
(c)	A and B independent implies		1.1b
	$P(A)\times 0.4 = 0.24$ or $(q + 0.16 + 0.24)\times 0.4 = 0.24$	M1	
	so P(A) = 0.6 and q = **0.20**	A1cso **(2)**	1.1b
(d)(i)	$P(B' \mid C) = 0.64$ gives $\frac{r}{r+p} = 0.64$ or $\frac{r}{r+"0.09"} = 0.64$	M1	3.1a
	$r = 0.64r + 0.64$ "p" so $0.36r = 0.0576$ so r = **0.16**	A1	1.1b
(ii)	Using sum of probabilities = 1 e.g. "0.6" + 0.07 + "0.25" + s =1	M1	1.1b
	so s = **0.08**	A1 **(4)**	1.1b
		(8 marks)	

	Notes
(a)	B1 for one correct pair. If more than one pair they must all be correct. Condone in a correct probability statement such as $P(A \cap C) = 0$ or correct use of set notation e.g. $A \cap C = \varnothing$ BUT e.g. "P(A) and P(C) are mutually exclusive" alone is B0
(b)	B1 for p = 0.09 (Maybe stated in Venn Diagram [VD]) [If values in VD and text conflict, take text or a value used in a later part]
(c)	M1 for a correct equation in one variable for P(A) or q using independence or for seeing **both** $P(A \cap B) = P(A)\times P(B)$ and $0.24 = 0.6\times 0.4$
	A1cso for q = 0.20 or exact equivalent (dep on correct use of independence)
Beware	Use of P(A) = 1 – P(B) = 0.6 leading to q = 0.2 scores M0A0
(d)(i)	1st M1 for use of $P(B' \mid C) = 0.64$ leading to a correct equation in r and possibly p. Can ft their p provided $0 < p < 1$
	1st A1 for r = 0.16 or exact equivalent
(ii)	2nd M1 for use of total probability = 1 to form a linear equation in s. Allow p, q, r etc Can follow through their values provided each of p, q, r are in [0, 1)
	2nd A1 for s = 0.08 or exact equivalent

Qu 2	Scheme	Marks	AO
(a)	Negative	B1 **(1)**	1.2
(b)(i) **(ii)**	Rainfall mm or Pressure hPa or Pascals or hectopascals or mb or millibars	B1 B1ft **(2)**	2.2b 1.1b
(c)	$H_0 : \rho = 0$ $H_1 : \rho \neq 0$ Critical value: $-0.361(0)$ $r < -0.3610$ so significant result and there is evidence of a correlation between Daily Total Sunshine and Daily Maximum Relative Humidity	B1 M1 A1 **(3)**	2.5 1.1b 2.2b
(d)	Humidity is high and there is evidence of correlation and $r < 0$ So expect amount of sunshine to be lower than the average for Heathrow(oe)	B1 **(1)**	2.2b
		(7 marks)	

	Notes
(a)	B1 for stating negative. "Negative skew" is B0 though
(b)(i)	B1 for mentioning "rainfall" (allow "rain" or "precipitation") or "pressure" (if more than 1 answer both must be correct) NB the other quantitative variable for Perth is: Daily Mean Wind Speed and scores B0 [Not allowed "wind speed" since $r = +0.15$ and in winter might expect wind to raise temp]
(ii)	B1ft for giving the correct units. If Daily Mean Wind Speed (kn) or knots "Wind speed" and "knots" would score B0B1 but any other variable scores B0B0
(c)	B1 for both hypotheses correct in terms of ρ M1 for the correct critical value compatible with their H_1: allow $\pm 0.361(0)$ If the hypotheses are 1-tail then allow cv of ± 0.3061 e.g. Alternative hypothesis with $r < \pm 0.377$ implies a one-tail test or H_0 and H_1 in words saying "H_0: there is no correlation, H_1: there is correlation" is two-tail If there are no hypotheses (or they are nonsensical) assume 2-tail so M1 for $\pm 0.361(0)$ A1 for a correct conclusion in context based on comparing -0.377 with their cv. Condone incorrect inequality e.g. $-0.3610 < -0.377$ as long as they reject H_0 Do not accept contradictory statements such as "accept H_0 so there is evidence of …" Can say "support for Stav's belief"(o.e.e.g. "claim") or "evidence of a correlation between sunshine and humidity" condone "negative correlation" or comments such as "if humidity is high amount of sunshine will be low"
(d)	B1 for stating low amount of sunshine (o. e.) **and** some reference to $r < 0$ or fog Check for the following 2 features: (i) **low** sunshine: allow $\leqslant 5$ hrs (LDS mean for 2015 is 5.3, humidity 97% is 4.1, $\geqslant 97\%$ is 3.1) (ii) **negative** correlation may be described in words e.g. "high humidity gives low sunshine" or **fog** (LDS says >95% humidity is foggy) so less sunshine

Qu 3	Scheme	Marks	AO
(a)	[68 – 7 =] **61** (only)	B1 **(1)**	1.1b
(b)	[25 – 14] = **11**	B1 **(1)**	1.1b
(c)	$\left[\mu \text{ or } \bar{x} = \frac{607.5}{27} = \right]$ = **22.5**	B1 **(1)**	1.1b
(d)	$\sigma = \sqrt{\frac{17\,623.25}{27} - "22.5"^2}$ or $\sqrt{146.4629...}$	M1	1.1b
	= 12.10218… awrt **12.1**	A1 **(2)**	1.1b
(e)	$\mu + 3\sigma = "22.5" + 3 \times "12.1..."$ = awrt 59 so only **one** outlier	B1ft **(1)**	1.1b
(f)	Median increases implies that both values must be > 20	M1	3.1b
	Mean is the same means that $a + b = 45$	M1	1.1b
	So possible values are: e.g. $b = 21$ and $a = 24$ (o.e.)	A1 **(3)**	2.2b
(g)	Both values will be less than 1 standard deviation from the mean and so the standard deviation of all 29 values will be smaller	B1 **(1)**	2.4
		(10 marks)	

Notes

(a) B1 for correctly interpreting the box plot to find the range (more than 1 answer is B0)

(b) B1 for correct understanding of IQR and answer of 11

(c) B1 for 22.5 only (or exact equivalent such as $\frac{45}{2}$). Allow 22 mins and 30 secs.

(d) M1 for a correct expression including square root. Allow $\sqrt{146}$ or better. Ft their mean
A1 for awrt 12.1 NB Allow use of s = 12.3327… or awrt 12.3

(e) B1ft for a correct calculation or value based on their μ and σ and compatible conclusion

(f) 1st M1 Correct start to the problem and a correct statement about the values based on median
Allow if their final two values are both >20
2nd M1 for a correct explanation leading to equation $a + b = 45$ (o.e. e.g. equidistant from mean)
Allow if their final two values sum to 45
A1 for a correct pair of values (both > 20 with a sum of 45) **and** at least some attempt to explain how their values satisfy at least one of the conditions (both > 20 or $a + b = 45$).
Ignore $a =$ or $b =$ labels
NB The values for a and b do not need to be integers.

(g) B1 for a correct explanation.
Must mention that both values are less than 1 sd (ft their answer to (d)) from the mean

Qu 4	Scheme	Marks	AO
(a)	$\frac{k}{10}+\frac{k}{20}+\frac{k}{30}+\frac{k}{40}+\frac{k}{50}=1$ or $\frac{1}{600}\left(60k+30k+20k+15k+12k\right)=1$	M1	1.1b
	So $k=\frac{600}{137}$ (*)	A1cso	1.1b
		(2)	
(b)	(Cases are:) $D_1=30, D_2=50$ and $D_1=50, D_2=30$ and $D_1=40, D_2=40$	M1	2.1
	$\mathrm{P}\left(D_1+D_2=80\right)=\frac{k}{50}\times\frac{k}{30}\times 2 + \left(\frac{k}{40}\right)^2$	M1	3.4
	= 0.0375619… awrt **0.0376**	A1	1.1b
		(3)	
(c)	Angles are: $a,\quad a+d,\quad a+2d,\quad a+3d$	M1	3.1a
	$S_4 = a + (a + d) + (a + 2d) + (a + 3d) = 360$	M1	2.1
	$2a + 3d = 180$ (o.e.)	A1	2.2a
	Smallest angle is $a > 50$ consider cases:	M1	3.1b
	$d = 10$ so $a = 75$ or $d = 20$ so $a = 60$ [$d = 30$ gives $a = 45$ no good]		
	$\mathrm{P}(D = 10 \text{ or } 20) = \frac{3k}{20} = \frac{90}{137}$	A1	1.1b
		(5)	
		(10 marks)	

	Notes
(a)	M1 for clear use of sum of probabilities = 1 (all terms seen)
	A1 cso (*) M1 scored and no incorrect working seen.
Verify	**(Assume $k = \frac{600}{137}$)** to score the final A1 they must have a final comment "$\therefore k = \frac{600}{137}$"
(b)	1st M1 for selecting at least 2 of the relevant cases (may be implied by their correct probs) e.g. allow 30, 50 and 50,30 i.e. D_1 and D_2 labels not required
	2nd M1 for using the model to obtain a correct expression for two different probabilities. May use letter k or their value for k.
	Allow for $\frac{k}{50}\times\frac{k}{30} + \left(\frac{k}{40}\right)^2$ or $2\times\left(\frac{k}{50}\times\frac{k}{30} + \left(\frac{k}{40}\right)^2\right)$
	A1 for awrt 0.0376 (exact fraction is $\frac{705}{18769}$)
(c)	1st M1 for recognising the 4 angles and finding expressions in terms of d and their a
	2nd M1 for using property of quad with these 4 angles (equation can be un-simplified) Allow these two marks for use of a (possible) value of d
	e.g. $a + a + 10 + a + 20 + a + 30 = 360$ (If at least 3 cases seen allow A1 for e.g. $4a = 300$)
	or allow M1M1 for a set of 4 angles with sum 360 and possible value of d (3 cases for A1)
	e.g. (for $d = 20$) 60, 80, 100, 120
	1st A1 for $2a + 3d = 180$ condition (o.e.) [Must be in the form $pa + qd = N$]
	3rd M1 for examining cases and getting $d = 10$ and $d = 20$ only
	2nd A1 for $\frac{90}{137}$ or exact equivalent
	The correct answer and no obviously incorrect working will score 5/5
	A final answer of awrt 0.657 (0.65693…) with no obviously incorrect working scores 4/5

Qu 5	Scheme	Marks	AO
(a)	{Let X = time spent, P(X > 15) = } 0.105649… awrt **0.106**	B1 **(1)**	1.1b
(b)	$H_0 : \mu = 10$ $H_1 : \mu > 10$	B1	2.5
	$\bar{X} \sim N\left(10, \left(\frac{4}{\sqrt{20}}\right)^2\right)$; $P\left(\bar{X} > 11.5\right)$ = 0.046766… [Condone 0.9532…]	M1;A1	3.3;3.4
	[This is significant (< 5%) so] there is evidence to support the complaint	A1 **(4)**	2.2b
(c)(i)	[P(T < 2) =] 0.1956… awrt **0.196**	B1 **(1)**	1.1b
(ii)	Require $\frac{P(0 < T < 2)}{P(T > 0)} = \frac{0.119119...}{0.923436...}$; = 0.1289955… awrt **0.129**	M1 A1;A1 **(3)**	3.4 1.1bx2
(iii)	The current model suggests **non-negligible** probability of T values < 0 which is impossible	B1 **(1)**	3.5b
(d)	Require t such that P($T > t \mid T > 2$) = 0.5 or P($T < t \mid T > 2$) = 0.5	M1	3.1b
	e.g. $\frac{P(T > t)}{P(T > 2)} = 0.5$; so P($T > t$) = 0.5×[1 – (c)(i)] or P($T > t$) = 0.5×0.8043..	M1; A1ft	1.1b 3.4
	[i.e. P($T > t$) = 0.40… implies] $\frac{t-5}{3.5} = 0.2533$ or P($T < t$) = "0.5978.."	M1	1.1b
	t = 5.886… or from calculator 5.867… so awrt **5.9**	A1 **(5)**	1.1b
		(15 marks)	

	Notes
(a)	B1 for awrt 0.106 (from calculator) [Allow 10.6%]
(b)	B1 for both hypotheses correct in terms of μ. M1 for selection of a correct model (sight or use of correct normal- may not have label $\bar{X}$) 1st A1 for use of this model to get probability allow 0.046~0.047 [Condone awrt 0.953]
ALT	**OR** test statistic z = 1.677… (awrt 1.68) and cv of 1.64 (or better) **or** CR $\bar{X}$ > 11.47.. 2nd A1 (dep on 1st A1 or at least $P\left(\bar{X} > 11.5\right)$ < 0.05 (o.e.))
SC	for a correct conclusion in context -must mention **complaint**/claim or **time**/mins is > 10 **(M0 for $\bar{X}$ ~N(11.5, …)** for correct probability **and** conclusion (score M0A0A1 on epen)
(c)(i)	B1 for awrt 0.196 (from calculator) [Allow 19.6%]
(ii)	M1 for a correct probability ratio expression (may be implied by 1st A1 scored) 1st A1 for a correct ratio of probabilities (both correct or truncated to 2 dp) 2nd A1 for awrt 0.129
(iii)	B1 for a suitable explanation of why model is not suitable based on negative T values Must say that a **significant** proportion of values < 0 (o.e.) e.g. P(T > 0) should be **closer** to 1 or Difference between P(T < 2| T > 0) and P(T < 2) is **too big** (o.e.)
(d)	1st M1 for a correct conditional probability statement to start the problem or 0.5×P(T > 2) 2nd M1 for correct ratio of probability expressions [Must have P($T > t$) or P(2 < $T < t$)] 1st A1ft for a correct equation for P($T > t$) (o.e.) ft their answer to part (c)[May be in a diagram] 3rd M1 for attempt to find t (standardising and sight of 0.2533) or prepare to use calc (ft) Arriving at P(T < median) = 1 – 0.5×"their 0.8043" will score 1st 4 marks 2nd A1 for awrt 5.9 Sight of awrt 5.9 and at least one M mark scores 5/5 [Answer only send to review]

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