Mark Scheme (Results)

Summer 2018

Pearson Edexcel GCE AS Mathematics

Statistics & Mechanics (8MA0/02)

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Summer 2018

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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 60.

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 $\sqrt{}$ 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.

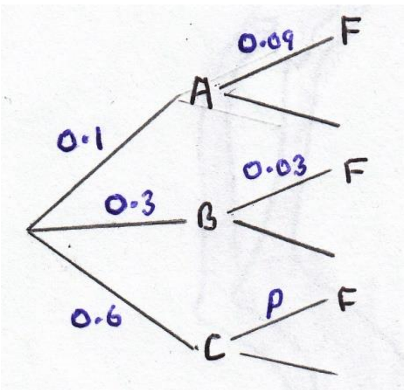
Section A: Statistics

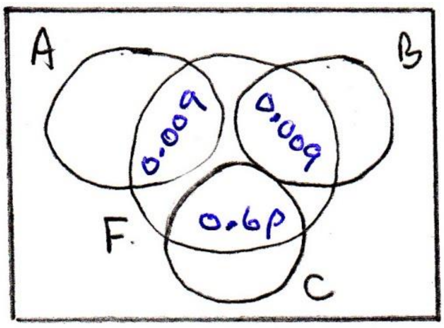
Qu	Scheme	Marks	AO
1 (a)	Positive (correlation)	B1 (1)	1.2
(b)	Every extra point gives £4.5(0) more on pay (o.e.)	B1 (1)	3.4
(c)	e.g. For points < 11 it would give pay < 0 which is ridiculous	B1 (1)	2.4
		(3 marks)	

	Notes
(a)	B1 for "positive". Allow an interpretation e.g. "as points increase pay increases" is B1 Read whole answer: contradictory comments such as "positive correlation, as points increase pay decreases" scores B0
(b)	B1 for any correct comment conveying idea of £s per point and including a correct value; must have idea of rate. Can condone missing £ sign. Accept 4.5 e.g. "every 10 points earns an extra (or increase) of £45" is B1 BUT "every point earns £4.5(0)" is B0 *doesn't have idea of rate*
(c)	B1 for a suitable comment mentioning "points" or "pay" (o.e. e.g. "amount") or commenting on "small sample" or "range of points" used to find line The following examples would score B1 Can say that n points (for $n < 10.\dot{4}$) would give negative pay so not suitable Any comment suggesting that some jobs would end up with negative pay Don't know the range of points used to find the regression line A small sample of size 8 may not be representative to cover all jobs B0 for a focus on "qualifications" or "hours" worked only The following examples would score B0 Some jobs require no (or low) skills or qualifications (*need negative pay*)

Qu	Scheme	Marks	AO
2 (a)	[Let p = P(F | C)] Tree diagram or some other method to find an equation for p $0.1\times0.09+0.3\times0.03+0.6\times p=0.06$ p = 0.07 i.e. **7%**	 M1 A1 A1 (3)	 2.1 1.1b 1.1b
(b)	e.g. P(B and F) = $0.3\times0.03 = 0.009$ but $\text{P}(B)\times\text{P}(F)=0.3\times0.06 = 0.018$ These are not equal so not independent	 B1 (1)	 2.4
		(4 marks)	

	Notes
(a)	M1 for selecting a suitable method to find the missing probability e.g. sight of tree diagram with 0.1, 0.3, 0.6 <u>and</u> 0.09, 0.03, p suitably placed e.g. sight of VD with 0.009 for $A\cap F$ and $B\cap F$ and 0.6p suitably placed <u>or</u> attempt an equation with at least one correct numerical and one "p" product (not necessarily correct) on LHS <u>or</u> for sight of 0.06 – (0.009 + 0.009) (o.e. e.g. 6 – 1.8 = 4.2%) 1st A1 for a correct equation for p (May be implied by a correct answer) <u>or</u> for the expression $\dfrac{0.06-(0.009+0.009)}{0.6}$ (o.e.) 2nd A1 for 7% (accept 0.07) **Correct Ans:** Provided there is no incorrect working seen award 3/3 e.g. may just see tree diagram with 0.07 for p (probably from trial and improv')
(b)	B1 for a suitable explanation…may talk about 2nd branches on tree diagram and point out that 0.03 $\neq$ 0.06 but need some supporting calculation/words Can condone incorrect use of set notation (it is not on AS spec) provided the rest of the calculations and words are correct.





Qu	Scheme	Marks	AO
3 (a)	Let N = the number of games Naasir wins $N \sim B(15, \frac{1}{3})$	M1	3.3
(i)	$P(N = 2) = 0.059946...$ **awrt 0.0599**	A1	1.1b
(ii)	$P(N > 5) = 1 - P(N \leqslant 5) = 0.38162...$ **awrt 0.382**	A1	1.1b
		(3)	
(b)	$H_0 : p = \frac{1}{3}$ $H_1 : p > \frac{1}{3}$	B1	2.5
	Let X = the number of games Naasir wins $X \sim B(32, \frac{1}{3})$	M1	3.3
	$P(X \geqslant 16) = 1 - P(X \leqslant 15) = 0.03765$ (< 0.05)	A1	3.4
	[Significant result so reject H_0 (the null model) and conclude:] There is evidence to support Naasir's claim (o.e.)	A1	3.5a
		(4)	
		(7 marks)	

	Notes
(a)	M1 for selecting a binomial model with correct n and p Award for sight of $B(15, \frac{1}{3})$ (o.e. e.g. in words) or implied by 1 correct answer 1st A1 for awrt 0.0599 (from a calculator). Allow 0.05995 2nd A1 for awrt 0.382 (from a calculator)
(b)	B1 for correctly stating both hypotheses in terms of p or π Accept $p = 0.\dot{3}$ or any exact equivalent. $H_1 : p \geqslant \frac{1}{3}$ is B0 M1 for selecting a suitable model to use for the test. Award for sight of $B(32, \frac{1}{3})$ (o.e. e.g. in words) or implied by 0.03765 Can also allow M1 for $P(X \leqslant 15) = 0.962$ or better or $P(X \leqslant 14) = 0.922$ or better 1st A1 for use of the model to calculate an appropriate probability using calc. Sight of $P(X \geqslant 16)$ **and** answer awrt 0.0377
ALT	**CR** May use CR so award 1st A1 for CR of $X \geqslant 16$ must have seen some probabilities though: 1 of $P(X \leqslant 15) = 0.9623$ or $P(X \leqslant 14) = 0.9224$ or 0.9223 2nd A1 for conclusion in context that there is support for Naasir's claim Must mention "Naasir" or "his" and "claim" or "method" (o.e.) or e.g. probability of winning a game is $> \frac{1}{3}$ or has increased Dependent on M1 and 1st A1 but can ignore hypotheses but see below If you see $P(X \geqslant 16) = 0.0376$ followed by a correct contextualised conclusion then please award A0A1
SC	**Use of 0.3 for $\frac{1}{3}$** If used 0.3 instead of $\frac{1}{3}$ in (a) and score M0A0A0 can condone use of 0.3 in (b) 1st A1 ft needs $P(X \geqslant 16) = 0.0138$ or CR of $X \geqslant 15$ and sight of 1 of $P(X \geqslant 15) = 0.0327$ or $P(X \geqslant 14) = 0.0694$

	2^{nd} A1 as before with 0.3 instead $\frac{1}{3}$ (if appropriate)

Qu	Scheme	Marks	AO
4 (a)	$\bar{x} = 10.2\,(2222\ldots)$ awrt **10.2**	B1 (1)	1.1b
(b)	$\sigma_x = 3.17\,(20227\ldots)$ awrt **3.17**	B1ft	1.1b
	Sight of "knots" <u>or</u> "kn" (condone knots/s etc)	B1 (2)	1.2
(c)	October ….. since	B1	2.2b
	it is windier in the autumn <u>or</u> month of the hurricane <u>or</u> latest month in the year	B1 (2)	2.4
(d)(i)	They represent <u>outliers</u>	B1	1.2
(ii)	Y has low median so expect lowish mean (but outlier so > 7) <u>and</u> Y has big range/IQR or spread so expect larger st.dev	M1	2.4
	Suggests B	A1 (3)	2.2b
		(8 marks)	

	Notes
NB	$\bar{x} = \dfrac{184}{18}$ and $\sigma_x = \sqrt{\dfrac{2062}{18} - \bar{x}^2}$
(a)	B1 for $\bar{x} = 10.2$ (allow exact fraction)
(b)	1st B1ft allow 3.2 from a correct expr' accept s = 3.26(3984…) [ft use of n/a] <u>Treating n/a as 0</u> May see n = 31 or $\bar{x} = 5.9354...$ which is B0 in (a) but here in (b) it gives σ_x = 5.59(34…) or s = 5.6858…(awrt 5.69) and scores 1st B1 2nd B1 accept kn accept in (a) or (b) (allow nautical miles/hour)
(c)	1st B1 choosing October but accept September. 2nd B1 for stating that (Camborne) is windier in autumn/winter months "because it is winter/autumn/windier/colder in "month" " Sep $\leqslant$ "month" $\leqslant$ Mar scores B1B1 for "month" = Sep or Oct and B0B1 for other months in range
(d)(i)	B1 for outlier or the idea of an extreme value allow "anomaly"
(ii)	M1 for a comment relating to location that mentions both median and mean <u>and</u> a comment relating to <u>spread</u> that mentions both range/IQR and standard deviation and leads to choosing B, C or D

	Choosing *A* or *E* is M0 Incorrect/false statements score M0 e.g. Q_3 = (mean + σ) or identify Q_2 = mean or *Y* has small spread
ALT	**Use of outliers:** outlier is **(**mean + 3σ) (B = 19.9), (C = 18.95), (D = 20.2) Must <u>see</u> at least one of these values and compare to *Y*'s outlier[leads to *D* or *B*] A1 for suitable inference i.e. *B* (accept *D* <u>or</u> *B* or *D*) M1 **must** be scored

Qu	Scheme	Marks	AO
5(a)	P(X = 4) = P(X = 2) so P(X = 4) = 0.35	M1	2.1
	P(X = 1) = P(X = 3) and P(X = 1) + P(X = 3) = 1 – 0.7		
	So	A1	1.1b
	<table><tr><td>x</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>P(X = x)</td><td>0.15</td><td>0.35</td><td>0.15</td><td>[0.35]</td></tr></table>		
		(2)	
(b)	Let A = number of spins that land on 4 A ~ B(60, "0.35")	B1ft	3.3
	[P(A > 30) =] 1 – P($A \leqslant$ 30)	M1	3.4
	= 1 – 0.99411… = **awrt 0.00589**	A1	1.1b
		(3)	
(c)	$Y - X \leqslant 4 \quad \Rightarrow \frac{12}{X} - X \leqslant 4$ or $12 - X^2 \leqslant 4X$ (since X > 0) o.e.	M1	3.1a
	i.e. $0 \leqslant X^2 + 4X - 12 \;\Rightarrow\; 0 \leqslant (X+6)(X-2)$ so $X \geqslant 2$	M1	1.1b
	$\mathrm{P}(Y - X \leqslant 4) = \mathrm{P}(X \geqslant 2) = 0.35 + 0.15 + 0.35$ **= <u>0.85</u>**	A1	3.2a
		(3)	
		(8 marks)	

	Notes
(a)	M1 for using the given information to obtain P(X = 4)
	Award for statement P(X = 4) = P(X = 2) <u>or</u> writing P(X = 4) = 0.35
	A1 for getting fully correct distribution (any form that clearly identifies probs)
	e.g. can be list P(X = 1) = 0.15, P(X = 3) = …etc or as a probability function $\mathrm{P}(X = x) = \begin{cases} 0.15 & x = 1, 3 \\ 0.35 & x = 2, 4 \end{cases}$
	[Condone missing P(X = 2) as this is given in QP]
(b)	B1 for selecting a suitable model, sight of B(60, their 0.35) o.e. in words f.t. their P(X = 4) from part (a).
	Can be implied by P($A \leqslant$ 30) = awrt 0.9941 or final answer = awrt 0.00589
	M1 for using their model and interpreting "more than half"
	Need to see 1 – P($A \leqslant$ 30) . Can be implied by awrt 0.00589
	Can ignore incorrect LHS such as P($A \geqslant$ 30)
	A1 for awrt 0.00589
(c)	1st M1 for translating the prob. problem into a <u>correct</u> mathematical inequality
	Just an inequality in 1 variable. May be inside a probability statement.
ALT	**Table of values:** <table><tr><td>X</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>Y</td><td>12</td><td>6</td><td>4</td><td>3</td></tr></table> <u>or</u> values of $Y - X$ = 11, 4, 1, – 1
	2nd M1 for solving the inequality leading to a range of values, allow 1 or 2 slips
	May be a quadratic or cubic but must lead to a set of values of X or $Y - X$
ALT	**Table or values:** They must state clearly which values are required
	Both Ms can be implied by a correct answer (or correct ft of their distb'n)
	A1 for interpreting the inequality and solving the problem i.e. 0.85 cao

Section B: Mechanics

Question	Scheme	Marks	AOs
6.	Equation in *t* only	M1	2.1
	$-2 = 9t - \frac{1}{2} \times 10t^2$	A1	1.1b
	$5t^2 - 9t - 2 = 0 = (5t+1)(t-2)$	DM1	1.1b
	$T = 2$ (only)	A1	1.1b
		(4)	
			(4 marks)

Notes:

M1: Complete method to give equation in *t* only. This mark is for a complete method for the TOTAL time i.e. for finding sufficient equations, with usual rules, correct no. of terms in each equation but condone sign errors and *g* does not need to be substituted

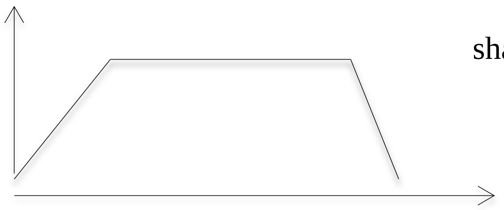
A1: A correct equation **or** correct equations (e.g. if they find the speed, 11 ms^{-1}, when the ball strikes the ground and then use that to find the total time **or** if they split the time (e.g. 0.9s up and 1.1s down or 0.9s + 0.9s + 0.2s))

N.B. $g = 10$ must be substituted in all equations used.

DM1: Dependent on first M1, for solving a 3 term quadratic to find *T* **or** for solving their equations to find *T* **or** for solving their equations and adding their split times to find *T*

A1: $T = 2$ only (i.e. A0 if they give two times)

N.B. If solving a correct quadratic, the DM1 can be implied by a correct answer i.e. the method does not need to be shown, but if there is no method shown and the answer is wrong then award DM0 A0.

Question	Scheme	Marks	AOs
7(a) (i)	24 ($\mathrm{m\,s^{-1}}$)	B1	1.1b
(ii)	48 (s)	B1	1.1b
(iii)	 shape	B1	1.1b
		(3)	
(b)	Equating area under graph to 4800 to give equation in one unknown	M1	3.1b
	$\frac{1}{2}(T+T+80+48)\times 24=4800$ **OR** $(\frac{1}{2}\times 80\times 24)+24T+(\frac{1}{2}\times 48\times 24)=4800$ **oe**	A1**ft**	1.1b
	T = 136 so total time is 264 (s)	A1	1.1b
		(3)	
(c)	Accept **Either**: a smooth change from acceleration to constant velocity or from constant velocity to deceleration. **Or** have train accelerating and/or decelerating at a variable rate Do not accept e.g. Comments on air resistance or resistive forces, straightness of track, horizontal track, friction, length of train, mass of train, not having train moving with constant velocity. <u>B0 if either an incorrect extra is included or an incorrect reason for a valid improvement is included.</u> <u>N.B.</u> Variable acceleration due to air resistance is B0 **BUT** Variable acceleration due to **variable** air resistance is B1	B1	3.5c
		(1)	
			(7 marks)

Notes:

(a)

(i) **B1:** 24 (m s^{-1})Must be stated i.e. not just inserted on the graph

(ii) **B1:** 48 (s) (Allow – 48 changed to 48) Must be stated i.e. not just inserted on the graph

(iii) B1: A trapezium starting at the origin and ending on the *t*-axis.

(b)

M1: Complete method to find area of trapezium using trapezium rule with correct structure or using two triangles and a rectangle and equate to 4800 to give equation in *one* unknown

N.B. $\frac{1}{2}(T+80+48)\times 24 = 4800$ is M0 (equivalent to using three triangles)

OR they may use *suvat* on one or more sections (must have a = 0 for middle section) and equate total distance travelled to 4800 to give equation in *one* unknown

A1ft: For a correct equation in their unknown **ft** on their 24 and 48 (but must be positive times)

A1: For 264 (s)

(c)

B1:

Either: Include time to change from constant accln to constant velocity and/or time to change from constant velocity to constant deceleration oe

Or: Have train accelerating and/or decelerating at a variable rate

Question	Scheme	Marks	AOs
8(a)	Multiply out and differentiate *wrt* to time (or use of product rule i.e. must have two terms with correct structure)	M1	1.1a
	$v = 2t^3 - 3t^2 + t$	A1	1.1b
	$2t^3 - 3t^2 + t = 0$ and solve: $t(2t-1)(t-1) = 0$	**DM**1	1.1b
	$t = 0$ or $t = \frac{1}{2}$ or $t = 1$; any two	A1	1.1b
	All three	A1	1.1b
		(5)	
(b)	Find x when $t = 0, \frac{1}{2}$, 1 and 2 : $(0, \frac{1}{32}, 0, 2)$	M1	2.1
	Distance = $\frac{1}{32} + \frac{1}{32} + 2$	M1	2.1
	$2\frac{1}{16}$ (m) oe or 2.06 or better	A1	1.1b
		(3)	
(c)	$x = \frac{1}{2}t^2(t-1)^2$	M1	3.1a
	$\frac{1}{2}$ perfect square so $x \geq 0$ i.e. never negative	A1 cso	2.4
		(2)	
			(10 marks)

Notes:

(a)

M1: Must have 3 terms and at least two powers going down by 1

A1: A correct expression

DM1: Dependent on first M, for equating to zero and attempting to solve a <u>cubic</u>

A1: Any two of the three values (Two correct answers can imply a correct method)

A1: The third value

(b)

M1: For attempting to find the values of x (at least two) at their t values found in (a) or at t =2 or equivalent e.g. they may integrate their v and sub in at least two of their t values

M1: Using a correct strategy to combine their distances (must have at least 3 distances)

A1: $2\frac{1}{16}$ (m) oe or 2.06 or better
(c) **M1:** Identify strategy to solve the problem such as: (i) writing x as $\frac{1}{2}\times$ perfect square (ii) or using x values identified in (b). (iii) or using calculus i.e. identifying min points on x–t graph. (iv) or using x-t graph. **A1 cso :** Fully correct explanation to show that $x \geq 0$ i.e. never negative

Question	Scheme	Marks	AOs
9(a)	Equation of motion for P	M1	3.3
	$2mg - T = 2m \times \frac{5g}{7}$	A1	1.1b
	$T = \frac{4mg}{7}$	A1	1.1b
		(3)	
(b)	Since the string is modelled as being inextensible	B1	3.4
		(1)	
(c)	Equation of motion for Q **OR** for whole system	M1	3.3
	$T - kmg = km \times \frac{5g}{7}$ **OR** $2mg - kmg = (km+2m)\frac{5g}{7}$	A1	1.1b
	$\frac{4mg}{7} - kmg = km \times \frac{5g}{7}$ oe and <u>solve for k</u>	DM1	1.1b
	$k = \frac{1}{3}$ or 0.333 or better	A1	1.1b
		(4)	
(d)	e.g The model does not take account of the mass of the string (see notes below for alternatives)	B1	3.5b
		(1)	
			(9 marks)

Notes: Condone both equations of motion appearing in (a) if used in (c)

(a)

M1: Resolving vertically for P with usual rules, correct no. of terms but condone sign errors and a does not need to be substituted (N.B. inconsistent omission of m is M0). Allow ma on RHS for M1

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

A1: A correct answer of form cmg, where $c = \frac{4}{7}$ oe or 0.57 or better

(b)

B1: String is inextensible. <u>N.B. B0 if any extras (wrong or irrelevant) given</u>

(c)

M1: Resolving vertically for Q or for a whole system equation, with usual rules, correct no. of terms but condone sign errors and neither T nor a does need to be substituted

(N.B. inconsistent omission of m is M0 and M0 if k is omitted from LHS or RHS or both.) **A1:** A correct equation (allow if they use 7 instead of $\frac{5g}{7}$) **DM1:** Sub for T using their answer from (a), if necessary, <u>and</u> solve to give a <u>numerical</u> value of k <u>(i.e. m's must cancel)</u> **A1:** $k = \frac{1}{3}$ or 0.333 or better.
(d) **B1:** e.g. Pulley may not be smooth Pulley may not be light Particles may not be moving freely e.g. air resistance Balls may not be particles String may not be light String may not be inextensible **(but allow converses in all cases e.g. 'pulley smooth')** *N.B.* B0 if <u>any extra incorrect answer</u> is given BUT ignore incorrect consequence of a correct answer. **Also note:** B0 : Use of a more accurate value of g

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