Paper 2: Statistics and Mechanics Mark Scheme

Question	Scheme	Marks	AOs
1(a)	Systematic (sample) cao	B1	1.2
(b)	In LDS some days have gaps because the data was not recorded	B1	2.4
(c)	$\left[\bar{t} = \frac{374}{20} = 18.7\right]$ $\sigma_t = \sqrt{\frac{7600}{20} - \bar{t}^2}$ $[= \sqrt{30.31}]$	M1	1.1a
	$= 5.5054\ldots$ awrt **<u>5.51</u>** (Accept use of $s_t = \sqrt{\frac{7600 - 20\bar{t}^2}{19}}$ $= 5.6484\ldots$)	A1	1.1b
			(4 marks)

Notes:

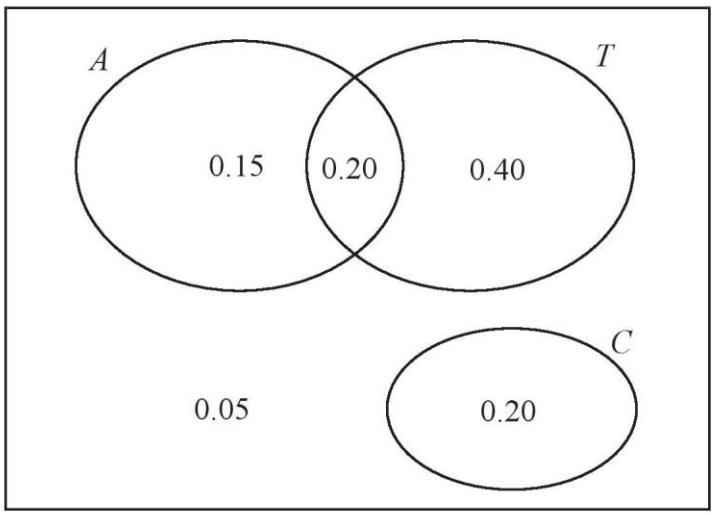
(b)
B1: A correct explanation

(c)
M1: For a correct expression for $\bar{t}$ and σ_t or s_t
ft an incorrect evaluation of $\bar{t}$
A1: For σ_t = awrt 5.51 or s_t = awrt 5.65

Question	Scheme	Marks	AOs
2	$17 + 45 + \frac{1}{3} \times 9$ $[= 65]$	M1	2.2a
	$(7 - 8)$ **<u>14</u>** or $(16 - 20)$ **<u>5</u>** [Values may be seen in the table]	M1 A1	3.1a 1.1b
	Percentage of motorists is $\frac{"65"}{6 + "14" + 17 + 45 + 9 + "5"} \times 100$	M1	3.1b
	$=$ **<u>67.7%</u>**	A1	1.1b
			(5 marks)

Notes:

M1: For a fully correct expression for the number of motorists in the interval
M1: For clear use of frequency density in (4- 6) or (13- 15) cases to establish the fd scale. Then use of area to find frequency in one of the missing cases
A1: For both correct values seen
M1: For realising that total is required and attempting a correct expression for %
A1: For awrt 67.7%

Question	Scheme	Marks	AOs
3(a)	$p = [1 - 0.75 - 0.05 =]$ **0.20**	B1	1.1b
		(1)	
(b)	$q =$ **0.15**	B1ft	1.1b
	$P(A) = 0.35 \quad P(T) = 0.6 \quad P(A \text{ and } T) = 0.20$ $\quad P(A) \times P(T) = 0.21$	M1	2.1
	Since $0.20 \neq 0.21$ therefore A and T are **not** independent	A1	2.4
		(3)	
			
(c)	P(not [A or C]) = **0.45**	B1	1.1b
		(1)	
			(5 marks)

Notes:

(a)

B1: cao for $p = 0.20$

(b)

B1: Ft for use of their p and P(A or T) to find q i.e. $0.75 - "p" - 0.40$ **or** $q = 0.15$

M1: For the statement of all probabilities required for a suitable test and sight of any appropriate calculations required

(c)

A1: All probabilities correct, correct comparison and suitable comment

B1: cao for 0.45

Question	Scheme	Marks	AOs
4(a)	IQR = 2.3 and $20.6 \gg 2.4 + 1.5 \times 2.3$ (= 5.85) (Compare correct values)	B1	1.1b
		(1)	
(b)(i)	e.g. It is a piece of data and we should consider all the data o.e.	B1	2.4
(ii)	e.g. It is an extreme value and could unduly influence the analysis **or** It could be a mistake	B1	2.4
		(2)	
(c)	e.g. "as humidity increases rainfall increases"	B1	2.2b
		(1)	
(d)	e.g. a 10% increase in humidity gives rise to a 1.5 mm increase in rainfall **or** represents 0.15mm of rainfall per percentage of humidity	B1	3.4
		(1)	
(e)(i)	Not a good method since only uses 11 days from one location in one month	B1	2.4
(ii)	e.g. She should use data from more of the UK locations and more of the months **or** using a spreadsheet or computer package she could use all of the available UK data	B1	2.4
		(2)	
			(7 marks)

Continued question 4
Notes:
(a) **B1:** For sight of the correct calculation and suitable comparison with 20.6
(b)(i) **B1**: For a suitable reason for including the data point
(b)(ii) **B1:** For a suitable reason for excluding the data point
(c) **B1:** For a suitable interpretation of positive correlation mentioning humidity and rainfall
(d) **B1:** For a suitable description of the rate: rainfall per percentage of humidity including reference to values
(e)(i) **B1:** For a comment that supports the idea that her sampling method was not a good one
(e)(ii) **BI:** For some sensible suggestions that would give a better representation of the data across the UK. Must show some awareness of the fact that LDS has different locations and more months of data available but must be clear they are NOT using any overseas locations
N.B. B0 for a comment that says use more than one location without specifying that only UK locations are required

Question	Scheme	Marks	AOs
5(a)	$P(X \geqslant 16) = 1 - P(X \leqslant 15)$	M1	1.1b
	$= 1 - 0.949077\ldots$ = awrt **<u>0.0509</u>**	A1	1.1b
		(2)	
(b)	$H_0 : p = 0.3$ $H_1 : p \neq 0.3$ (Both correct in terms of p or π)	B1	2.5
		(1)	
(c)	$[Y \sim B(20, 0.3)]$ sight of $P(Y \leqslant 2) = 0.0355$ or $P(Y \leqslant 9) = 0.9520$	M1	2.1
	Critical region is $\{Y \leqslant \mathbf{2}\}$ or (o.e.)	A1	1.1b
	$\{Y \geqslant \mathbf{10}\}$ (o.e.)	A1	1.1b
		(3)	
(d)	$[0.0355 + (1 - 0.9520)] = 0.0835$ **or** **<u>8.35%</u>**	B1ft	1.1b
		(1)	
(e)	(Assuming that the 20 customers represent a random sample then) 12 is in the CR so the manager's suspicion is supported	B1ft	3.2a
		(1)	
(f)	e.g. (e) requires the 20 customers to be a random sample or independent and the members of the scout group may invalidate this so binomial distribution would not be valid (and conclusion in (e) is probably not valid)	B1	3.5a
		(1)	
			(9 marks)

Continued question 5
Notes:
(a) **M1:** For dealing with P($X \geqslant 16$) – they need to use cumulative prob. function on calc **A1:** awrt 0.0509 (from calculator)
(b) **B1**: For both hypotheses in terms of p or π and H_1 must be 2-tail
(c) **M1:** For correct use of tables to find probability associated with critical value **A1:** For the correct lower limit of the CR. Do not award for P($Y \leqslant 2$) **A1:** For the correct upper limit
(d) **B1:** ft on their 0.0355 and (1 – their 0.9520) provided each probability is less than 0.05
(e) **B1:** ft for a comment that relates 12 to their CR and makes a consistent comment relating this to the manager's suspicion
(f) **BI:** For a comment that: gives a suitable reason based on lack of independence **or** the sample not being random **so** the binomial model is not valid

Question	Scheme	Marks	AOs
6.	Using distance = total area under graph (e.g. area of rectangle + triangle **or** trapezium **or** rectangle – triangle)	M1	2.1
	e.g. $D = UT + \frac{1}{2} Th$, where h is height of triangle	A1	1.1b
	Using gradient = acceleration to substitute $h = aT$	M1	1.1b
	$D = U T + \frac{1}{2} aT^2$ *	A1 *	1.1b
		(4)	
			(4 marks)

Notes:
M1: For use of distance = total area to give an equation in D, U, T and one other variable **A1:** For a correct equation **M1:** For using gradient = a to eliminate the other variable to give an equation in D, U, T and a *only* **A1*:** For a correct given answer

Question	Scheme	Marks	AOs
7(i)(ii)	Using a correct strategy for solving the problem by setting up two equations in a and u only and solving for either	M1	3.1b
	Equation in a and u only	M1	3.1b
	$22 = 2u + \frac{1}{2} a 2^2$	A1	1.1b
	Another equation in a and u only	M1	3.1b
	$126 = 6u + \frac{1}{2} a 6^2$	A1	1.1b
	5 m s^{-2}	A1	1.1b
	6 m s^{-1}	A1ft	1.1b
			(7 marks)

Notes:

M1: For solving the problem by setting up two equations in a and u only and solving for either
M1: Use of (one or more) *suvat* formulae to produce an equation in u and a only
A1: For a correct equation
M1: Use of (one or more) *suvat* formulae to produce another equation in u and a only
A1: For a correct equation
A1: For correct accln 5 m s^{-2}
A1: For correct speed 6 m s^{-1} (The second of these A marks is an **ft** mark, following an incorrect value for u or a, depending on which has been found first)

N.B. Do not award the ft mark for absurd answers e.g. $a > 15$, $u > 50$

See alternative on the next page

ALTERNATIVE

Question	Scheme	Marks	AOs
7(i)(ii)	Using a correct strategy for solving the problem by obtaining actual speeds at two times and using a = change in speed / time taken	M1	3.1b
	Actual speed at $t = 1$ = Average speed over interval	M1	3.1b
	$22/2 = 11$	A1	1.1b
	Actual speed at $t = 4$ = Average speed over interval	M1	3.1b
	$104/4 = 26$	A1	1.1b
	$5\ \text{m s}^{-2}$	A1	1.1b
	$6\ \text{m s}^{-1}$	A1ft	1.1b
			(7 marks)

Notes:

M1: For solving the problem by obtaining two actual speeds and use of $a = (v - u)/t$
M1: Use of speed at half-time = av speed over interval to produce a speed at $t = 1$
A1: For a correct speed
M1: Use of speed at half-time = av speed over interval to produce a speed at $t = 4$
A1: For a correct speed
A1: For correct accln $5\ \text{m s}^{-2}$
A1: ft for correct speed $6\ \text{m s}^{-1}$ (This is an ft mark, following an incorrect value of a)

N.B. Do not award the ft mark for absurd answers e.g. $a > 15$, $u > 50$

Question	Scheme	Marks	AOs
8(a)	Substitution of both $t = 0$ and $t = 10$	M1	2.1
	$s = 0$ for both $t = 0$ and $t = 10$	A1	1.1b
	Explanation ($s > 0$ for $0 < t < 10$) since $s = \frac{1}{10}t^2(t-10)^2$	A1	2.4
		(3)	
(b)	Differentiate displacement s w.r.t. t to give velocity, v	M1	1.1a
	$v = \frac{1}{10}(4t^3 - 60t^2 + 200t)$	A1	1.1b
	Interpretation of 'rest' to give $v = \frac{1}{10}(4t^3 - 60t^2 + 200t) = \frac{2}{5}t(t-5)(t-10) = 0$	M1	1.1b
	$t = 0, 5, 10$	A1	1.1b
	Select $t = 5$ and substitute their $t = 5$ into s	M1	1.1a
	Distance = 62.5 m	A1ft	1.1b
		(6)	
			(9 marks)

Notes:

(a)

M1: For substituting $t = 0$ and $t = 10$ into s expression

A1: For noting that $s = 0$ at both times

A1: Since s is a perfect square, $s > 0$ for all other t- values

(b)

M1: For differentiating s w.r.t. t to give v (powers of t reducing by 1)

A1: For a correct v expression in any form

M1: For equating v to 0 and factorising

A1: For correct t values

M1: For substituting their intermediate t value into s

A1: ft following an incorrect t-value

Question	Scheme	Marks	AOs
9(a)(i)	Equation of motion for A	M1	3.3
	$T - 12.7 = 2.5a$	A1	1.1b
(ii)	Equation of motion for B	M1	3.3
	$1.5g - T = 1.5a$	A1	1.1b
		(4)	
(b)	Solving two equations for a	M1	1.1b
	$a = 0.5$	A1	1.1b
		(2)	
(c)	$1 = \frac{1}{2} \leftarrow 0.5\, t^2$	M1	3.4
	$t = 2$ seconds	A1ft	1.1b
		(2)	
(d)	Valid improvement, see below in notes	B1	3.5c
	Valid improvement, see below in notes	B1	3.5c
		(2)	
			(10 marks)

Continued question 9
Notes:
(a)(i) **M1:** For resolving horizontally for A **A1:** For a correct equation
(a)(ii) **M1:** For resolving vertically for B **A1:** For a correct equation
(b) **M1:** For complete correct strategy for solving the problem, setting up **two** equations in a, and then solving them for a **A1:** For $a = 0.5$
(c) **M1:** For a complete method (which could involve use of more than one *suvat* formula) to give an equation in t only **A1:** Ft from their a to get time in seconds
(d) **B1, B1** for any two of e.g. Include the dimensions of the ball in the model so that the distance it falls changes e.g. Include the dimensions of the pulley in the model so string not parallel to table e.g. Include a variable resistance in the model instead of taking it to be constant e.g. Include a more accurate value for g in the model