

Version 1.0



General Certificate of Education (A-level)
June 2012

Mathematics

MS/SS1B

(Specification 6360)

Statistics 1B

Mark Scheme

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Key to mark scheme abbreviations

| | |
|--------------|--|
| M | mark is for method |
| m or dM | mark is dependent on one or more M marks and is for method |
| A | mark is dependent on M or m marks and is for accuracy |
| B | mark is independent of M or m marks and is for method and accuracy |
| E | mark is for explanation |
| √ or ft or F | follow through from previous incorrect result |
| CAO | correct answer only |
| CSO | correct solution only |
| AWFW | anything which falls within |
| AWRT | anything which rounds to |
| ACF | any correct form |
| AG | answer given |
| SC | special case |
| OE | or equivalent |
| A2,1 | 2 or 1 (or 0) accuracy marks |
| -x EE | deduct x marks for each error |
| NMS | no method shown |
| PI | possibly implied |
| SCA | substantially correct approach |
| c | candidate |
| sf | significant figure(s) |
| dp | decimal place(s) |

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

MS/SS1B

| Q | Solution | Marks | Total | Comments |
|--------------|---|-------|----------|---|
| 1 (a) | $r = \frac{S_{xy}}{\sqrt{S_{xx} \times S_{yy}}} = \frac{-0.410}{\sqrt{2.030 \times 1.498}} = \underline{-0.235}$ | M1 | 2 | Correct substitution into correct formula May be implied by a correct answer |
| | | A1 | | AWRT (-0.235115) |
| (b) | <p>Some / (very) weak / (very) little / (very) slight negative correlation/relationship/association/link between width and thickness of lengths of steel</p> | Adep1 | 2 | Dependent on -0.235 or -0.24 OE; must qualify strength and state negative Ignore extra words unless contradict Not 'no', 'low', 'small', 'unlikely' or 'trend' |
| | | B1 | | Context; do not allow 'cms' or 'mms' |
| SC | $r = (+)0.235 \Rightarrow$ M1 A0 Adep0 B1 max | | | |
| Total | | | 4 | |

| Q | Solution | Marks | Total | Comments |
|--------------|---|-------|-----------|--|
| 2 (a)(i) | Mode = <u>23</u> | B1 | 1 | CAO |
| | | | | |
| (ii) | Median (88 th value) = <u>22</u> | B1 | 3 | CAO |
| | Upper quartile (132 nd value) = <u>23</u> | B1 | | CAO; either May be implied by IQR = 3 |
| | Lower quartile (44 th value) = <u>20</u> | B1 | | |
| | Interquartile range = <u>3</u> | B1 | | CAO; do not award if seen to be not based on 23 and 20 |
| (b) | Mean = <u>22.3</u> | B2 | 4 | CAO; but only award B1 (22.3) if incorrect mid-points or Σfx seen AWFW ($\Sigma fx = 3902.5$) |
| | Mean = <u>21 to 23</u> | (B1) | | |
| | Standard deviation = <u>6.37 or 6.39</u> | B2 | | AWRT ($s = 6.391$ $\sigma = 6.372$) |
| | Standard deviation = <u>5 to 7</u> | (B1) | | AWFW ($\Sigma fx^2 = 94132.25$) |
| SC | <p>Only if B0 B0 or B1 B0 then award as follows but only up to a maximum total part mark of 2</p> <p>1 At least 2 correct mid-points 4.5, 14.5, 27, 32, 37, 44.5, 54 seen \Rightarrow M1</p> <p>2 Clear use of $\Sigma fx / (175$ or $174) \Rightarrow$ M1</p> | | | |
| (c) | $\text{Mean} = (\text{c's mean from (b)}) + \frac{280}{175}$ $= 22.3 + 1.6$ | M1 | 2 | Adding (1.6 or equivalent) CAO to (c's mean from (b)) or to (c's new mean) |
| | Mean = <u>23.9</u> | AF1 | | F on (c's mean from (b)) or on (c's new mean) |
| Total | | | 10 | |

MS/SS1B (cont)

| Q | Solution | Marks | Total | Comments |
|--------------|--|--|-----------|---|
| 3 (a) | b (gradient) = <u>2.27</u> b (gradient) = <u>2.2 to 2.3</u> a (intercept) = <u>4.16 to 4.2</u> a (intercept) = <u>3 to 7</u> Attempt at $\sum x$ $\sum x^2$ $\sum y$ & $\sum xy$ ($\sum y^2$) or Attempt at S_{xx} & S_{xy} (S_{yy}) Attempt at correct formula for b (gradient) b (gradient) = <u>2.27</u> a (intercept) = <u>4.16 to 4.2</u> | B2 (B1) B2 (B1) (M1) (m1) (A1) (A1) | 4 | AWR T (2.27075) AWF W <i>Treat rounding of correct answers as ISW</i> AWF W (4.16981) AWF W 480 24500 1140 & 57635 (135908) (all 4 attempted) 5300 & 12035 (27608) (both attempted) AWR T AWF W |
| Notes | 1 Values of a and b interchanged and equation $y = ax + b$ stated in (a) \Rightarrow max of 4 marks 2 Values of a and b interchanged and equation $y = a + bx$ stated in (a) \Rightarrow 0 marks 3 Values are not identified or simply $a = \#$ and $b = \#$, then 2.2 to 2.3 \Rightarrow B1 and 3 to 7 \Rightarrow B1 but accept, for example, as identification, [$a = \#, b = \#$ with $y = a + bx$ but no substitution for a & b] or [intercept(a) = #, gradient(b) = #] 4 $b = \frac{2407}{1060}$ CAO \Rightarrow B2, otherwise B1 if fraction equates to 2.2 to 2.3 (Notes 1, 2 & 3 also apply) $a = \frac{221}{53}$ CAO \Rightarrow B2, otherwise B1 if fraction equates to 3 to 7 (Notes 1, 2 & 3 also apply) 5 Some/all of marks can be scored in (b), and in c(ii) & (iii), even if some/all of marks are lost in (a) but marks lost in (a) cannot be recouped by subsequent working in (b) | | | |
| (b) | Correct straight line drawn on scatter diagram Correct shortened and/or freehand line drawn on scatter diagram | B2 (B1) | 2 | Line must go from $x \leq 20$ to $x \geq 70$ and fall between the following 2 lines: Lower: (10, 25) (80, 180) Upper: (10, 30) (80, 190) |
| Notes | 1 If B0 but seen correct attempt at ≥ 2 points even if incorrectly evaluated \Rightarrow M1 2 If B0 but no seen evidence to support ≥ 2 points (correct or incorrect) marked on scatter diagram \Rightarrow M0 | | | |
| (c)(i) | Correct straight line drawn on scatter diagram Correct shortened and/or freehand line drawn on scatter diagram | B2 (B1) | 2 | Line must go from $x \leq 20$ to $x \geq 70$ and fall between the following 2 lines: Lower: (10, 60) (80, 75) Upper: (10, 65) (80, 85) |
| Notes | 1 If B0 but seen correct attempt at ≥ 2 points even if incorrectly evaluated \Rightarrow M1 2 If B0 but no seen evidence to support ≥ 2 points (correct or incorrect) marked on scatter diagram \Rightarrow M0 | | | |
| (ii) | $\underline{27 to 29}$ | B1 | 1 | AWF W (calculation \Rightarrow 27.75) Must clearly identify x -value Thus (27 to 29, y -value) \Rightarrow B0 |
| (iii) | At low temperatures more B (than A) dissolves At high temperatures more A (than B) dissolves Amount increases more rapidly for A (than B) Amount increases more slowly for B (than A) | B1 B1 | 2 | Either; OE (eg a comparison using lines and/or data at a specific temperature but not at 0°C) Either; OE Any comments about b or a \Rightarrow B0 Comment about 'rate' must relate to temp |
| Total | | | 11 | |

MS/SS1B (cont)

| Q | Solution | Marks | Total | Comments |
|--------------|---|----------------------|-----------|---|
| 4 | | | | Ratios (eg 194:640) are only penalised by 1 accuracy mark at first correct answer |
| (a)(i) | $P(B = 3) =$ <u>194/640 or 97/320 or 0.303 or 30.3%</u> | B1 | 1 | CAO or AWRT (0.303125) |
| (ii) | $P(T \geq 2) = \frac{172 + 256 + 135}{640}$ or $1 - \frac{77}{640}$ or $\frac{563}{640}$ $=$ <u>563/640</u> <u>or (0.879 to 0.88) or (87.9% to 88%)</u> | M1 A1 | 2 | CAO AWFW (0.879688) |
| (iii) | $P(B = 3 \ \& \ T \geq 2) =$ $\frac{72 + 99 + 16}{640}$ or $\frac{194 - 7}{640}$ or $\frac{187}{640}$ $=$ <u>187/640 or 0.292 or 29.2%</u> | M1 A1 | 2 | CAO or AWRT (0.292188) |
| (iv) | $P(B \leq 3 \mid T = 2) =$ $\frac{(14 + 67 + 72)}{172}$ or $\frac{172 - 19}{172}$ or $\frac{153}{172}$ $=$ <u>153/172</u> <u>or (0.888 to 0.89) or (88.8% to 89%)</u> | M1 M1 A1 | 3 | Correct numerator (accept both $\div 640$) Correct denominator CAO AWFW (0.889535) |
| (b) | (a)(i) \times (a)(ii) \neq (a)(iii) since $0.303 \times 0.88 =$ <u>0.265 to 0.27 \neq 0.292</u> | M1 A1 | 2 | Answers as fractions, percentages or ratios lose accuracy (A & B) marks in (b) & (c) Attempted AWFW & AWRT |
| SC | Any correct fully-explained reasoning, using other than answers from part (a), which results in an inequality (\neq) with both sides as numerically correct decimals (to 3 dp) \Rightarrow B1 (eg $P(B = 3) = 0.303 \neq P(B = 3 \mid T = 2) = 72/172 = 0.419$) but no/unclear/incomplete reasoning or no/incorrect/incomplete numerical work \Rightarrow B0 | | | |
| (c) | $P(2T \cap 3T \cap \geq 4T \mid B = 3) = \frac{72}{194} \times \frac{99}{193} \times \frac{16}{192}$ abc multiplied by 6 or 3 $=$ <u>0.095 to 0.0952</u> | M1 M1 M1 A1 | 4 | Correct 3 values multiplied in numerator Correct 3 values multiplied in denominator $0.371 \times 0.513 \times 0.083$ (all AWRT) \Rightarrow M1 M1 (OE products) $0 < (a, b \ \& \ c) < 1$ AWFW (0.095187) |
| Notes | 1 Incorrect answer with no working \Rightarrow 0 marks 2 The 3 correct fractions/decimals identified but not multiplied (eg added) \Rightarrow M1 M0 M0 A0 3 The 3 correct fractions/decimals identified together with 0.016 (AWRT) \Rightarrow M1 M1 M0 A0 4 A denominator of ${}^{194}C_3 = 1198144 \Rightarrow$ M2 (2 nd & 3 rd M1 marks) | | | |
| | Total | | 14 | |

MS/SS1B (cont)

| Q | Solution | Marks | Total | Comments |
|----------|--|----------|-----------|---|
| 5 | | | | In (a)(i) & (c), ignore the inclusion of a lower limit of 0; it has no effect on either answer |
| (a) | <u>Weight, $W \sim N(2.75, 0.15^2)$</u> | | | |
| (i) | $P(W < 2.8) = P\left(Z < \frac{2.8 - 2.75}{0.15}\right)$ | M1 | | Standardising 2.8 with 2.75 and 0.15; allow (2.75 – 2.8) |
| | $= P(Z < \underline{0.33 \text{ or } 1/3})$ | A1 | | AWRT/CAO; ignore inequality and sign May be implied by a correct answer |
| | $= \underline{0.629 \text{ to } 0.633}$ | A1 | | AWFW (0.63056) |
| (ii) | $P(W > 2.5) = P(Z > -1.67) = P(Z < +1.67)$ | M1 | | Correct area change May be implied by a correct answer or an answer > 0.5 |
| | $= \underline{0.951 \text{ to } 0.953}$ | A1 | 5 | AWFW (0.95221) |
| (b) | <u>Weight, $X \sim N(5.25, 0.20^2)$</u> | | | |
| (i) | $P(5.1 < X < 5.3) = P(Z < 0.25) - P(Z < -0.75)$ $= \underline{0.59871}$ MINUS [(1 – 0.77337) or 0.22663] $= \underline{0.372(08)}$ | B1 B1 | 2 | Must have diff of 2 probs for each B1 Accept 0.599 Accept 0.773 or 0.227 AG; do not mark simply on answer |
| (ii) | $P(0 \text{ in } 4) = [1 - 0.372]^4$ | M1 | | Accept [1 – c’s (b)(i)] ⁴ |
| | $= 0.628^4 = \underline{0.155 \text{ to } 0.156}$ | A1 | 2 | AWFW (0.15554) |
| (c) | <u>Weight, $Y \sim N(10.75, 0.50^2)$</u> | | | |
| | Variance of $\bar{Y}_6 = \underline{0.5^2/6 = 0.0416 \text{ to } 0.0417}$ or Sd of $\bar{Y}_6 = \underline{0.5/\sqrt{6} = 0.204}$ | B1 | | CAO or AFWW Stated or used CAO or AWRT |
| | $P(\bar{Y}_6 < 10.5) = P\left(Z < \frac{10.5 - 10.75}{\sqrt{0.0416}}\right) =$ | M1 | | Standardising 10.5 with 10.75 and $\sqrt{0.0416}$ OE; allow (10.75 – 10.5) |
| | $P(Z < -1.22) = 1 - P(Z < 1.22) =$ | m1 | | Correct area change May be implied by a correct answer or an answer < 0.5 ; but do not award for use of $z = \pm 0.22$ |
| | $1 - (0.88877 \text{ to } 0.89065) = \underline{0.109 \text{ to } 0.112}$ | A1 | 4 | AWFW (0.11034) (1 – answer) \Rightarrow B1 M1 max |
| | Total | | 13 | |

MS/SS1B (cont)

| Q | Solution | Marks | Total | Comments |
|---------------|---|-------|---|---|
| 6 | | | | |
| (a)(i) | $U \sim B(30, 0.13, 0.35 \text{ or } 0.20)$ | M1 | | Used correctly anywhere in (a) |
| | $P(P = 2) = \binom{30}{2}(0.13)^2(0.87)^{28}$ | A1 | | Can be implied by a correct answer |
| | $= \underline{0.148 \text{ to } 0.15}$ | A1 | 3 | AWFW (0.1489) |
| (ii) | $p = \underline{0.35}$ | B1 | | CAO |
| | $P(R \cup P > 10) = \underline{1 - (0.5078 \text{ or } 0.3575)}$ | M1 | | Requires '1 -' Accept 3 dp rounding or truncation Can be implied by 0.49 to 0.493 but not by 0.642 to 0.643 |
| | $= \underline{0.49 \text{ to } 0.493}$ | A1 | 3 | AWFW (0.4922) |
| (iii) | $P(5 \leq G \leq 10) = \underline{0.9744 \text{ or } 0.9389}$ (p_1) | M1 | | Accept 3 dp rounding or truncation |
| | MINUS $\underline{0.2552 \text{ or } 0.4275}$ (p_2) | M1 | | Accept 3 dp rounding or truncation |
| | $= \underline{0.719 \text{ to } 0.72}$ (p_3) | A1 | 3 | AWFW (0.7192) |
| Notes | <p>1 $p_3 \leq 0$ or $p_3 \geq 1 \Rightarrow$ M0 M0 A0</p> <p>2 $p_2 - p_1 \Rightarrow$ M0 M0 A0</p> <p>3 $(1 - p_2) - p_1 \Rightarrow$ M0 M0 A0</p> | | <p>4 $p_1 - (1 - p_2) \Rightarrow$ M1 M0 A0</p> <p>5 $p_1 \times p_2 \Rightarrow$ M1 M0 A0</p> <p>6 $(1 - p_2) - (1 - p_1) \Rightarrow$ M1 M1 (A1)</p> | |
| (b)(i) | Mean or $\mu = 100 \times 0.22 = \underline{22}$ | B1 | | CAO |
| | Variance or $\sigma^2 = 100 \times 0.22 \times 0.78$ | | | |
| | $= \underline{17.1 \text{ to } 17.2}$ | B1 | 2 | AWFW (ignore notation) (17.16) ISW all subsequent working |
| (ii) | 22.1 \approx 22 or means similar/equal or 0.221 \approx 0.22 or proportions similar/equal so reject claim (that $p > 0.22$) or accept that $p = 0.22$ | B1 | | Dependent on 22 seen in (b)(i) or (ii) Accept diff = 0.1 CAO Correct (numerical) comparison with correct conclusion (even if at end and stated as 'reject (both) claims') |
| | $\sqrt{17.1 \text{ to } 17.2} = \underline{4.13 \text{ to } 4.15 \approx 4.17}$ | | | |
| | or | B1 | | Comparison using two values or one value + diff (0.02 to 0.04 AFWF) |
| | $\underline{17.1 \text{ to } 17.2 \approx 17.3 \text{ to } 17.4}$ | | | |
| | so reject claim that not random samples or accept that are random samples | Bdep1 | 3 | Dependent on previous B1 Correct conclusion regarding randomness of sample |
| | Total | | 14 | |

MS/SS1B (cont)

| Q | Solution | Marks | Total | Comments |
|--|---|---|---|---|
| 7 (a) | $\bar{x} = \frac{181.8}{36} =$ <u>5.05 or 5050</u> | B1 | 5 | CAO |
| | 98% (0.98) $\Rightarrow z =$ <u>2.32 to 2.33</u> | B1 | | AWFW (2.3263) |
| | CI for μ is $\bar{x} \pm z \times \frac{\sigma}{\sqrt{n}}$ | M1 | | Used with z (2.05 to 2.58), \bar{x} (5.05, 5050 or 181.8), σ (0.0075, 0.075, 0.75, 7.5 or 75) and $\div\sqrt{n}$ with $n > 1$ |
| | Thus $5.05 \pm 2.3263 \times \frac{0.075}{\sqrt{36}}$ | A1 | | z (2.05 to 2.06 or 2.32 to 2.33 or 2.57 to 2.58), \bar{x} (5.05) & σ (0.075) or \bar{x} (5050) & σ (75) and $\div\sqrt{36}$ or 35 |
| Hence <u>5.05 \pm 0.03 or 5050 \pm 30</u> | Adep1 | 5 | CAO/AWRT Dependent on previous A1 so can be scored with $z \neq 2.32$ to 2.33 Ignore (absence of) quoted units AWRT to 3sf accuracy | |
| OR <u>(5.02, 5.08) or (5020, 5080)</u> | | | | |
| Note | Use of t (2.43 to 2.72) \Rightarrow B1 B0 M1 A0 A0 max | | | |
| (b) | Clear correct comparison of 5 or 5000 with LCL or CI so agree with (first) claim (about mean) | Adep1 | 3 | Dependent on Adep1 in (a) Must use consistent units |
| | (8/36 or 0.22 or 22%) v (1/10 or 0.10 or 10%) or 8 v 3.6 (3 to 4) | B1 | | Mention of a value on LHS and a value on RHS |
| | so 8/36 OE $>/\neq$ 1/10 OE so disagree with (second) claim (about individuals) | Bdep1 | | Dependent on B1 Explicit comparison of values and correct conclusion |
| Notes | 1 It/(claimed) mean/(claimed) value < LCL/CI \Rightarrow Adep0 2 98% have (mean) weights between CLs so ... \Rightarrow Adep0 3 Any reference to CI for second claim \Rightarrow B0 Bdep0 | Must indicate 5 or 5000 Claim refers to individual bottles | | |
| (c) | Yes because volumes/bleach/litres/bottles/ (parent) population are not (stated as) normally distributed | B1 | 1 | OE; but do not accept 'data' or 'sample' or 'it' Reference to sample size only \Rightarrow B0 (eg $n > 25$ or $n > 30$) |
| | Total | | 9 | |
| | TOTAL | | 75 | |