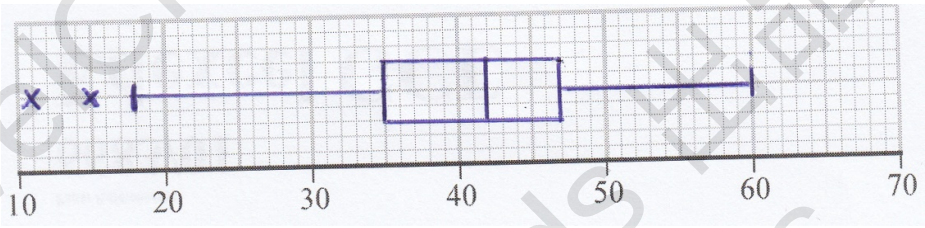
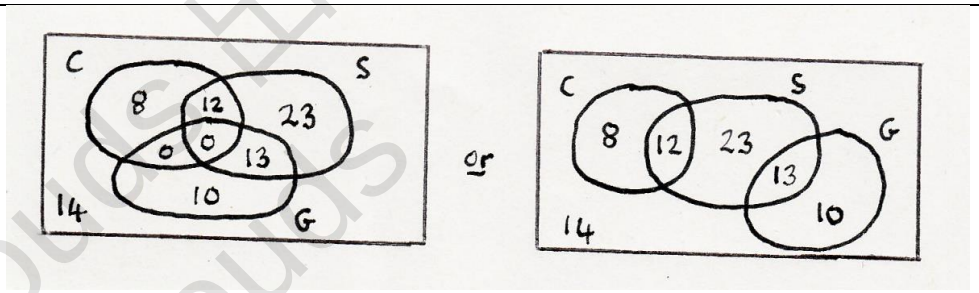
| Question Number | Scheme | Marks |
|---|---|---|
| **1. (a)(i)** | [IQR = 47 – 33 =] **14** | B1 |
| **(ii)** | [Range = 54 – 11 =] **43** | B1 (2) |
| **(b)** | e.g. $Q_2 - Q_1 (=9) > (5=) Q_3 - Q_2$ | M1 |
| | Therefore negative (skew) | A1 (2) |
| **(c)** | $25 \rightarrow 37 \Rightarrow$ new $Q_1 = 35$ (may be on box plot) | B1 |
| | [$54 \rightarrow 60$ (implies upper whisker now at 60) but no change to $Q_3$ ] | |
| | New IQR = 12 so need to re-calculate for outliers | M1 |
| | Outliers now [ > 47 + 18 = 65 or] < 35 – 18 = 17 | A1 |
| | **Box Plot**   | |
| | Box and two whiskers with median still at 42 | M1 |
| | Lower quartile at their 35 ( ≠ 33 ) and upper quartile unchanged at 47 | A1ft |
| | Two outliers at 11 and 15 | A1 |
| | Lower whisker at 18 (or 17) and upper whisker at 60 | A1 (7) |
| **(d)** | The value of pmcc is small or weak correlation (o.e.) | M1 |
| | Therefore the complaint is not supported | A1 (2) |
| | | **[13]** |

| | Notes |
|---|---|
| **(a)(i)** | 1st B1 for 14<br>2nd B1 for 43 |
| **(b)** | M1 for a suitable reason or calculation (allow longer whisker on left etc)<br>A1 for negative skew (dep on M1 seen) "left skew" etc is A0 [Condone incorrect "9" or "5"] |
| **(c)** | B1 for new lower quartile at 35 (stated or on box plot)<br>1st M1 for finding the new IQR (< 14) and attempting to re-calculate for outliers<br>1st A1 for at least the correct lower limit of 17 seen<br>2nd M1 for drawing a box with only two whiskers and median at 42 (all points ± 0.5 square)<br>2nd A1ft for lower quartile of "35" (changed from 33) and upper quartile unchanged at 47<br>3rd A1 for only two outliers at 11 and 15 (no overlap with whisker)<br>4th A1 for lower whisker ending at 18 (or 17) and upper whisker ending at 60<br>Correct box plot scores all except 1st M1A1 (i.e. 5/7) this M1A1 requires some working |
| **(d)** | M1 for comment that pmcc is "small" so little correlation (just saying < 0 is not enough)<br>Allow e.g. "not significant" or "not relevant" or $-0.5 < r < 0.5$ or "not close to – 1 " but "no correlation" is M0<br>A1 for suggesting the complaint is not supported e.g. "little evidence to support claim"<br>Dep on M1 seen NB M1A0 is possible |

| Question Number | Scheme | Marks |
|---|---|---|
| **2. (a)** |   | B1<br>B1<br>B1<br>B1<br>(4) |
| **(b)(i)** | $P(S) = \left\lfloor \frac{12+23+13}{80} \right\rfloor = \frac{48}{80}$ or $\frac{3}{5}$ or 0.6 | B1ft<br>(1) |
| **(ii)** | $P(S \mid C) = \frac{P(S \cap C)}{P(C)} = \frac{\frac{12}{80}}{\frac{20}{80}}$<br>$= \frac{12}{20}$ or 0.6 | M1<br>A1cso<br>(2) |
| **(iii)** | $P(S) = P(S\|C)$ or $P(C) = 0.25$, $P(C \cap S) = 0.15$ and $P(C) \times P(S) = 0.6 \times 0.25$<br>so $S$ and $C$ are independent | B1ft<br>dB1ft<br>(2) |
| **(c)** | Need $P(S \mid G) = \frac{13}{23}$<br>$P(S \mid C) = 0.6 > 0.565$ so assistant selling coats has the better performance | M1A1<br>A1<br>(3)<br>**[Total 12]** |

| | Notes |
|---|---|
| **(a)** | 1st B1 for 3 labelled circles with 12, 13 & $n(C \cap G) = 0$ marked or implied (e.g.RH diagram)<br>2nd B1 for 8 and 10 correctly placed<br>3rd B1 for 23 correctly placed<br>4th B1 for box and 14<br>May use probabilities not integers<br>A blank space does not imply a zero |
| **(b)(i)** | B1ft for 0.6 or any exact equivalent (single fraction) or ft their values (ft blank as 0) |
| **(ii)** | M1 for a correct conditional prob. Correct expression and one correct ft prob. Num < Den<br>A1cso for 0.6 which must come from a denominator of 20 |
| **(iii)** | 1st B1ft for a full reason. If not $P(S) = P(S\|C)$ then all values must be stated, labelled and correct or correct ft from diagram. Correct not'n required so $P(S \cup C) = 0.15$ is B0B0<br>2nd dB1ft dep. on a correct reason for correct conclusion for their values |
| **(c)** | M1 for attempt at $P(S \mid G)$ correct ratio of probabilities or numbers using their figs<br>1st A1 for $\frac{13}{23}$ (accept awrt 0.565) [Sight of $P(S \mid G) = \frac{13}{23}$ is M1A1]<br>2nd A1 for a correct conclusion that chooses "coats" based on a correct comparison<br>Allow incorrect $P(S\|C)$ provided > 0.565 to score 2nd A1 and so all 3 marks<br>Condone poor use of notation eg $S\|G$ with no P(..). Probabilities may be described in words.<br>Condone comparison of $\frac{13}{23}$ with 0.6 even if $\frac{13}{23}$ is not labelled as $P(S\|G)$ |

| Question Number | Scheme | Marks |
|---|---|---|
| **3. (a)** | [Discrete] **uniform** (BUT continuous uniform is B0) | B1 (1) |
| **(b)** | $P(D = 3) + P(D = 1) \times P(D = 2) = \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} = \frac{5}{16}$ **(*)** | M1A1cso (2) |
| **(c)** | $[P(D = 1) \times P(D = 1) = \frac{1}{4} \times \frac{1}{4}$ or $1 - \left(\frac{1}{4} + \frac{5}{16} + \frac{5}{16} + \frac{1}{16}\right) =]$ $\frac{1}{16}$ | B1 (1) |
| **(d)** | $E(X) = 0 + 2 \times \frac{1}{4} + 3 \times \frac{5}{16} + 4 \times \frac{5}{16} + 5 \times \frac{1}{16} = \mathbf{3}$ | M1A1 (2) |
| **(e)** | $E(X^2) = 0 + 2^2 \times \frac{1}{4} + 3^2 \times \frac{5}{16} + 4^2 \times \frac{5}{16} + 5^2 \times \frac{1}{16} = [\frac{166}{16}$ or $\frac{83}{8}$ or $10.375]$<br>$\text{Var}(X) = \frac{166}{16} - 3^2$<br>$\sigma_X{}^2 = 1.375$ or $\frac{11}{8}$ | M1<br>dM1<br>A1 (3) |
| **(f)** | $r$ \| 1 \| 2<br>$P(R = r)$ \| $\frac{3}{4}$ \| $\frac{1}{4}$ | M1<br>A1 (2) |
| **(g)** | $E(R) = 1 \times \frac{3}{4} + 2 \times \frac{1}{4}$ $[= 1.25$ o.e.$]$<br>$E(Y) = 2E(R) + 0.5$<br>$= 2.5 + 0.5 = 3$ **(*)**<br>$y$ \| 2.5 \| 4.5<br>$P(Y = y)$ \| $\frac{3}{4}$ \| $\frac{1}{4}$<br>$E(Y) = 2.5 \times \frac{3}{4} + 4.5 \times \frac{1}{4}$ | M1<br>M1<br>A1cso (3) |
| **(h)** | $R = 1$ so $Y = 2.5 \Rightarrow X = D = 2$ or 3 or 4 so $D = 3$ or 4 work and prob $= \frac{1}{4} + \frac{1}{4}$<br>May use $P(X > 2.5 \mid R = 1) = \frac{2}{3}$ then prob will be $\frac{2}{3} \times \frac{3}{4}$<br>$R = 2$ so $Y = 4.5 \Rightarrow D = 1$ then $X = 0$, 3 or 4 or 5 so $X = 5$ only prob $= \frac{1}{16}$<br>So $P(X > Y) = \frac{1}{4} + \frac{1}{4} + \frac{1}{16} = \frac{9}{16}$ | M1<br>M1<br>A1 (3)<br>**[Total 17]** |

| | Notes |
|---|---|
| **(b)** | M1 for a correct expression in terms of $P(D)$ or with $\frac{1}{4}$s for $P(X = 3)$<br>A1cso M1 scored and no incorrect working seen $[P(X = 0) + P(X = 3)$ is M0A0 if identified!] |
| **(d)** | M1 for an attempt i.e. an expression with at least 3 correct products seen<br>A1 for 3 or an exact equivalent e.g. $\frac{48}{16}$ |
| **(e)** | 1st M1 for an attempt i.e. an expression with at least 3 correct products seen[implied by $\frac{166}{16}$ ]<br>2nd dM1 dep on 1st M1 for use of $\text{Var}(X) = E(X^2) - E(X)^2$ must see values but ft their values<br>A1 for 1.375 or an exact equivalent |
| **(f)** | M1 for one correct value of $r$ and it's associated probability<br>A1 for a fully correct probability distribution – needn't be in a table |
| **(g)** | 1st M1 for correct expression for $E(R)$ [ft their (f)] or 1.25 or correct distribution for $Y$[ft (f)]<br>2nd M1 for correct use of $E(Y) = 2E(R) + 0.5$ or correct expr'n for $E(Y)$ [ft (f)] [$\Rightarrow$ 1st M1]<br>A1cso for 3 with no incorrect working seen provided both Ms are scored |
| **(h)** | 1st M1 for cases where $R = 1$ **and** prob. 2nd M1 for cases where $R = 2$ **and** prob<br>A1 for $\frac{9}{16}$ or exact equivalent |

| Question Number | Scheme | Marks |
|---|---|---|
| **4 (a)** | $\bar{x} = \frac{58}{40} =$ **1.45** | B1 |
| | $\sigma^2 = \frac{84.829}{40} - 1.45^2$ | M1 |
| | $= 0.018225$ = awrt **0.0182** | A1 |
| | | (3) |
| **(b)** | New mean = **145** | B1ft |
| | New $\sigma$ = **13.5** | B1 |
| | | (2) |
| **(c)(i)** | **Reason** e.g. mean of two extra children is the same as the original mean | M1 |
| | **Conclusion** the mean is therefore unchanged or = **145** | A1 |
| **(ii)** | **Reason** e.g. extra children more than 1 sd from mean so increased spread | M1 |
| | **Conclusion** therefore standard deviation will increase | A1 |
| | | (4) |
| | | **[9]** |

**Notes**

**(a)**
B1 for a correct mean (accept an exact fraction)
M1 for a correct expression for $\sigma^2$ (or $s^2$) (ft their mean and condone inside square root)
A1 for awrt 0.0182 (NB $s^2 = 0.0186923\ldots$ awrt 0.0187) **Correct ans only** 2/2 [No fraction]

**(b)**
1st B1ft for new mean = 145 or $100 \times$ their $\bar{x}$
2nd B1 for new s.d. = awrt 13.5 (accept $s = 13.6719\ldots$ or awrt 13.7)

**(c)(i)**
1st M1 for a suitable reason. May see recalculation e.g. $\frac{"145" \times 40 + 130 + 160}{42}$ (o.e.)
e.g. "both 15 away from the mean" or " both same distance from the mean" or "mean of new values is 145 or the same"
1st A1 for 145 or 1.45 or "no change" but M1 must be seen
[no further comment needed if answer matches their (b) or (a)]

**(ii)**
2nd M1 for a suitable reason but must have idea that the "gap" (= 15) > 1 st. dev. [ft $\sigma < 15$]
2nd A1 for stating standard deviation will be greater (o.e.) [M1 must be seen]
**Calculations** (You may see)
e.g. $\Sigma y^2 = 84.829 + 1.3^2 + 1.6^2 = 89.079$ leading to $\sigma = \sqrt{0.01842...} = 0.13575\ldots$ or 13.6 (cm)
or $\frac{89.079}{42} = 2.1209... > \frac{84.829}{40} = 2.1207...$ but $\frac{\sum x}{n}$ stays the same so $\sigma$ greater
BUT M0A0 unless we see mention of 15 (cm) or 1.5 (m) being more than 1 sd

| Question Number | Scheme | Marks |
|---|---|---|
| **5. (a)** | [It supports because:] $r$ is close to –1 <u>or</u> there is strong correlation. | **B1** **(1)** |
| **(b)** | e.g. The dependent variable. The variable being studied. | **B1** **(1)** |
| **(c)** | $[b = \frac{S_{ch}}{S_{cc}} =] \frac{-3034.6}{303448} = -0.01[000...\text{hours/mg}]$ | **M1 A1** |
| | So the data support the statement. (o.e.) | **dA1** **(3)** |
| **(d)** | $a = \bar{h} - b\bar{c} = \frac{126}{20} - "-0.01.." \times \frac{3660}{20} = 6.3 - "-0.01..." \times 183 = 8.13\ldots$ **awrt <u>8.1</u>** | **M1 A1ft** **A1** **(3)** |
| | | **[8 marks]** |

**Notes**

**(b)** B1 Allow equivalent definitions e.g. the variable you can't control in an experiment.
<u>or</u> the amount of sleep <u>depends</u> on the amount of caffeine
<u>or</u> is affected by (changes according to) another variable
BUT "can't be measured" is B0

**Mark (c) and (d) together. Gradient: M1 & 1st A1 in (c) Intercept: M1 & 1st A1 in (d)**

**(c)** M1 for calculation of gradient (correct expression)
1st A1 for awrt $-0.01$ must be seen to come from gradient (can be part of whole equation)
2nd dA1 dependent on M1 and 1st A1 for "claim is supported" <u>or</u> "Martin is correct"
<u>or</u> "reduces by 1 hour"

**2nd A1** If whole equation is seen before 2nd A1 attempted they must refer to just gradient
**2nd A1** <u>or</u> May use equation to calculate $h$ for some $c$ and then $c + 100$ to show loss of 1 hour
If they use the intercept and $c = 100$, must see a clear subtraction (e.g. 8.13 – 7.13) to score

**(d)** M1 for attempt to find $a$ for linear regression model
(Use of letter $b$ or ft their value of $b$ but a correctly placed $\bar{h}$ or $\bar{c}$ needed)
1st A1ft for correct expression for $a$ (follow through their value for $b$)
2nd A1 for awrt 8.1 (hours) (or 8 hours and awrt 8 minutes) [ Allow 8.1.. – 0 ]

| Question Number | Scheme | Marks |
|---|---|---|
| **6. (a)** | $P(L > 4.3) = P\left(Z > \frac{4.3-4.1}{0.125}\right)$ | M1 |
| | $= P(Z > 1.6)$ <u>or</u> $1 - P(Z < 1.6)$ <u>or</u> $1 - 0.9452$ | M1 |
| | $= 0.0548$ | A1 (3) |
| **(b)** | $P(3.9 < L < 4.3) = P(Z < 1.6) - P(Z < -1.6)$ or $2(P(Z < 1.6) - 0.5)$ | |
| | $= 0.9452 - 0.0548$ $= 2(0.9452 - 0.5)$ | |
| | $= 0.8904$ $= 0.8904$ | B1cso (1) |
| **(c)** | Number of unusable bolts $= (1-0.89)\times 500$ [$= 55$] | M1oe |
| | Value of bolts $= "445"\times 9 + "55"\times 1$ | M1oe |
| | profit $= "445"\times 9 + "55"\times 1 - 500\times 5$ | M1oe |
| | Profit from bolts $= 1560$ pence | A1 |
| | <u>Alternative</u> | |
| | E(value of a bolt) $= 0.89\times 9 + 0.11\times 1$ | M1oe |
| | E(profit per bolt) $= 0.89\times 9 + 0.11\times 1 - 5$ | M1oe |
| | Profit $= "3.12"\times 500$ | M1oe |
| | Profit from bolts $= 1560$ pence | A1 (4) |
| **(d)** | $\frac{4.198-\mu}{\sigma} = 1.96$ **or** $4.198 - \mu = 1.96\sigma$ **oe** | M1A1 |
| | $\frac{4.065-\mu}{\sigma} = -0.7$ **or** $4.065 - \mu = -0.7\sigma$ **oe** | A1 |
| | $0.133 = 2.66\sigma$ | M1 |
| | $\sigma = 0.05$ ( or awrt 0.0500) | A1 |
| | $\mu = 4.1$ (or awrt 4.10) | A1 (6) |
| **(e)** | The mean the same but the st. dev. decreased **or** $P(3.9 < L < 4.3)$ increased. | B1ft |
| | So the profit will increase | dB1ft (2) |
| | NB Use of + 0.7 in (c) $\rightarrow \mu = 3.99, \sigma = 0.106,$ prob $\approx 0.80 \rightarrow$ profit down | **Total 16** |

| | **Notes** |
|---|---|
| **(a)** | 1st M1 standardising. Allow use of $0.125^2$<br>2nd M1 $1-p$ $p > 0.8$<br>A1 awrt 0.0548 |
| **(b)** | B1cso sight of 0.8904 or better (calc: 0.8904014212…) or a correct subtraction |
| **(c)** | 1st M1 $(1-"0.89")\times 500$ <u>or</u> $0.89\times 9 + 0.11\times 1$<br>2nd M1 $"445"\times 9 + "55"$ <u>or</u> $0.89\times 9 + 0.11\times 1 - 5$<br>3rd M1 method for the profit <u>or</u> their $"3.12"\times 500$<br>A1 for awrt £15.60 or 1560 pence(p) [need units] |
| | **SC** think 55 scrap **loses** 1p<br>1st M1 for sight of 55<br>B1 for answer of awrt 1450 p<br>Score as: M1M0M0A1 |
| **(d)** | 1st M1 Forming either equation – must have $z$ value but allow $\pm z$ where $\lvert z\rvert > 0.6$<br>1st A1 correct equation $4.198 - \mu = 1.96\sigma$ - any form (or allow $z$ = awrt 1.960)<br>2nd A1 correct equation $4.065 - \mu = -0.7\sigma$ - any form (or allow $z$ = awrt – 0.700)<br>2nd M1 eliminating $\mu$ or $\sigma$ (method <u>seen</u> leading to equation in 1 variable)<br>3rd A1 0.05 (or awrt 0.0500) 4th A1 4.1 (or awrt 4.10 dep on 1st or 2nd A1)<br>NB Candidate who assumes $\mu = 4.1$ can get M1 A0 A0M1A0A1 |
| **(e)** | 1st B1ft if $\mu = 4.1$ then ft σ ; if $\mu < 3.9$ (allow any $\sigma$) <u>otherwise</u> need to see $P(3.9<L<4.3)$ calc<br>If they have $\mu = 4.1$ in part (d) then don't need to state "mean the same" in part (e)<br>2nd dB1ft therefore profit will increase (o.e.) [ $\sigma < 0$ is B0B0] |