Version 1.0



**General Certificate of Education (A-level)**
**June 2013**

# Mathematics MS03

# (Specification 6360)

# Statistics 3

# Final

# *Mark Scheme*

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from: aqa.org.uk

Copyright © 2013 AQA and its licensors. All rights reserved.

**Copyright**
AQA retains the copyright on all its publications. However, registered schools/colleges for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to schools/colleges to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX.

**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.**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **1(a)** | 98% $\Rightarrow$ $z =$ **2.32 to 2.33** | B1 | | AWFW (2.3263) |
| | Approximate CI for $\lambda$: $\hat{\lambda} \pm z\sqrt{\hat{\lambda}}$ | M1 | | Used |
| | $392 \pm 2.3263 \times \sqrt{392}$ | AF1 | | F on $z$ |
| | Per shift $\Rightarrow$ $\div 12$ | M1 | | |
| | Thus: **32.7 ± 3.8 or (28.8, 36.5)** | A1 | 5 | AWRT |
| **(b)** | Per hour (weekday night) $\Rightarrow$ **(2.05 to 2.06, 2.6 to 2.61)** | BF1 | | F on (a) |
| | Per hour (weekend) $= \frac{136.8}{48} =$ **2.85** | B1 | | |
| | Thus evidence to **agree with claim** | BF1 | 3 | F on comparison of value with CI<br>Definitive conclusion $\Rightarrow$ BF0 |
| | **Total** | | **8** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **2(a)** | **A** **B**<br>E(0.15) 0.135<br>T(0.9) T(0.75) 0.675<br>L(0.10) 0.090<br>T(0.35) 0.035<br>L(0.1)<br>L(0.65) 0.065 | B1<br>B1<br>B1 | 3 | Correct shape<br>Correct labels<br>Correct probabilities |
| **(b)(i)** | $P(E \cup T \text{ @ } B) = 0.9 \times 0.9 + 0.1 \times 0.35$ | M1 | | $1 - (0.09 + 0.065)$ |
| | $= \underline{\mathbf{0.84 \text{ to } 0.85}}$ | A1 | 2 | AWFW (0.845) |
| **(ii)** | $P(T \text{ @ } A \mid T \text{ @ } B) = \dfrac{0.9 \times 0.75}{(0.9 \times 0.75 + 0.1 \times 0.35)}$ | M1<br>m1 | | P(A \| B) **used in (ii) or (iii)**<br>$a \div (a + b)$ with at least $a$ correct |
| | $= \dfrac{0.675}{0.71} = \underline{\mathbf{0.95 \text{ to } 0.951}}$ | A1 | 3 | AWFW (0.95070) |
| **(iii)** | $P(L \text{ @ } A \mid L' \text{ @ } B) = \dfrac{0.1 \times 0.35}{\text{(i)}}$ | AF1 | | F on (i) |
| | $= \dfrac{0.035}{0.845} = \underline{\mathbf{0.04 \text{ to } 0.042}}$ | A1 | 2 | AWFW (0.04142) |
| **(c)** | $P((T \text{ @ } A \mid L \text{ @ } B) \cap (T' \text{ @ } A \mid L \text{ @ } B))$ | | | |
| | $\dfrac{0.9 \times 0.1}{1 - 0.845} \times \dfrac{0.1 \times 0.65}{1 - 0.845} \times 2$ | M1<br>M1<br>M1 | | First expression (18/31)<br>Second expression (13/31)<br>$\times 2$ |
| | $= \underline{\mathbf{0.486 \text{ to } 0.49}}$ | A1 | 4 | AWFW (0.48699) |
| | **Total** | | **14** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **3(a)** | 95% $\Rightarrow$ $z = \underline{\mathbf{1.96}}$ | B1 | | AWRT |
| | $\bar{x} = \underline{\mathbf{1026}}$ $\quad \bar{y} = \underline{\mathbf{1045}}$ | B1 | | Both CAO |
| | CI for $\mu_Y - \mu_X$ is<br>$(\bar{y} - \bar{x}) \pm z\sqrt{\frac{\sigma_Y^2}{n_Y} + \frac{\sigma_X^2}{n_X}}$ | M1<br>m1 | | Used<br>Accept $(\bar{x} - \bar{y})$ throughout<br>SD term |
| | ie<br>$(1045 - 1026) \pm 1.96\sqrt{\frac{30^2}{8} + \frac{25^2}{10}}$ | AF1 | | F on $\bar{x}$, $\bar{y}$ and $z$ |
| | ie $\quad 19 \pm 25.9$ or $(-6.9, 44.9)$ | A1 | | CAO & AWRT or AWRT |
| | ie $\quad \underline{\mathbf{20 \pm 25 \text{ or } (-5 \text{ or } -10, 45)}}$ | B1 | 7 | Rounding answer to nearest 5 kg |
| **(b)** | Fred used:<br>machine X for sand and machine Y for gravel | B1 | | Apparent rounding to nearest 5 kg |
| | Use each machine for both | B1 | 2 | OE |
| | **Total** | | **9** | |
| **4** | $H_0$: $p_M - p_D = 0.10$<br>$H_1$: $p_M - p_D > 0.10$ | B1<br>B1 | | If B0 B0, then<br>award B1 for $p_M - p_D = 0$ |
| | 95% $\Rightarrow$ $z = \underline{\mathbf{1.64 \text{ to } 1.65}}$ | B1 | | AWFW (1.6449) |
| | $z = \frac{(\hat{p}_M - \hat{p}_D) - 0.10}{\sqrt{\frac{\hat{p}_M(1-\hat{p}_M)}{n_M} + \frac{\hat{p}_D(1-\hat{p}_D)}{n_D}}} =$ | M1<br>m1 | | Used; allow pooling and/or 'no –0.10'<br>Denominator |
| | $\frac{(0.38 - 0.21) - 0.10}{\sqrt{\frac{0.38 \times 0.62}{250} + \frac{0.21 \times 0.79}{100}}} =$ | A1 | | Correct expression but allow 'no –0.10' |
| | $\frac{0.07}{0.051} = \underline{\mathbf{1.37}}$ | A1 | | AWRT (1.3724) |
| | **No evidence**, at 5% level, to suggest that the difference is more than 10 per cent | AF1 | 8 | F on CV and $z$-value<br>Definitive conclusion $\Rightarrow$ AF0 |
| | **Total** | | **8** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **5(a)(i)** | $L = X + Z$ | | | |
| | $E(L) = 68 + 73$ **<u>141</u>** | B1 | | CAO |
| | $V(L) = 10^2 + 15^2 =$ **<u>325</u>** | B1 | 2 | CAO |
| **(ii)** | $M = X + Y$ | | | |
| | $E(M) = 68 + 25 =$ **<u>93</u>** | B1 | | CAO |
| | $V(M) = 10^2 + 5^2 + 2 \times 10 \times 5 \times (-0.8)$ | M1 | | Allow 'no 2' |
| | $= 100 + 25 - 80 =$ **<u>45</u>** | A1 | 3 | CAO |
| **(b)(i)** | Require: $P(L < 150) =$ | | | |
| | $P\left(Z < \frac{150-141}{\sqrt{325}}\right)$ | M1 | | Standardising 150 using c's $E(L)$ & c's $V(L)$ from (a)(i) |
| | $= P(Z < 0.5)$ | | | (0.49923) |
| | = **<u>0.69 to 0.692</u>** | A1 | 2 | AWFW (0.69119) |
| **(ii)** | Require: $P(X + Y > 105) = P(M > 105)$ | | | |
| | $= P\left(Z > \frac{105-93}{\sqrt{45}}\right)$ | M1 | | Standardising 105 using c's $E(M)$ & c's $V(M)$ from (a)(ii) |
| | $= P(Z > 1.79) = 1 - P(Z < 1.79)$ | m1 | | **Correct** area change (1.78885) May be implied by a **correct** answer **or** by an answer **< 0.5** |
| | = **<u>0.036 to 0.038</u>** | A1 | 3 | AWFW (0.03682) |
| | **Total** | | **10** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **6(a)(i)** | $\lambda = 6 \times 2.5 = \underline{\mathbf{15}}$ | B1 | | CAO |
| | $P(W \leq 18) = \underline{\mathbf{0.819 \text{ to } 0.82}}$ | B1 | 2 | AWFW (0.8195) |
| **(ii)** | $P(W > w) \leq 0.05 \Rightarrow P(W \leq w) \geq 0.95$ | M1 | | Implied by a value of 21, 22 or 23 |
| | $w = \underline{\mathbf{22}}$ | A1 | 2 | CAO |
| **(b)(i)** | $F \sim \underline{\mathbf{N(30, 30)}}$ | B1 | | May be implied |
| | $P(F > 35) =$ | | | |
| | $P\left(Z > \frac{35.5-30}{\sqrt{30}}\right) = P(Z > 1.00)$ | M1 | | Standardising (34.5, 35 or 35.5) with $\mu = \sigma^2$ |
| | | B1 | | 35.5 (1.00416) |
| | $= \underline{\mathbf{0.157 \text{ to } 0.16}}$ | A1 | 4 | AWFW (0.15765) |
| **(ii)** | $P(F > f) \leq 5\% \Rightarrow$ | | | |
| | $P\left(Z > \frac{(f+0.5)-30}{\sqrt{30}}\right) \leq 0.05$ | M1 | | Standardising ($f - 0.5$, $f$ or $f + 0.5$) with $\mu = \sigma^2$ |
| | $5\% \Rightarrow z = \underline{\mathbf{1.64 \text{ to } 1.65}}$ | B1 | | AWFW (1.6449) |
| | So $f = \underline{\mathbf{39}}$ | Adep1 | 3 | CAO<br>Dependent on $(f + 0.5)$ and on B1 |
| | **Total** | | **11** | |

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **7(a)** | $H_0$: $p = 0.50$<br>$H_1$: $p > 0.50$ | B1<br>B1 | | Here or in (b)(i) |
| | $P(X \geq 29 \mid B(50, 0.50)) =$<br>**1 – (0.8389 or 0.8987)** | M1<br>M1 | | Use of B(50, 0.50); may be implied |
| | = **0.16 to 0.165** | A1 | | AWFW (0.16112) |
| | **No evidence** to support the claim | AF1 | 6 | F on 10% and ($p$-value > 0.10)<br>Definitive conclusion ⇒ AF0 |
| **(b)(i)** | 10% ⇒ $z$ = **1.28** | B1 | | AWRT (1.2816) |
| | $z = \dfrac{\frac{271}{500} - 0.5}{\sqrt{\frac{0.5 \times 0.5}{500}}}$ = **1.87 to 1.89** | M1<br>A1 | | Accept use of $\hat{p}$ in denominator giving $z$ = 1.88511<br>AWFW (1.87830) |
| | **Evidence** to support the claim | AF1 | 4 | F on CV and $z$-value<br>Definitive conclusion ⇒ AF0 |
| **(ii)** | Power = 1 – P(Type II error)<br>= 1 – P(accept $H_0$ \| $H_0$ false)<br>or P(reject $H_0$ \| $H_0$ false)<br>or P(accept $H_1$ \| $H_1$ true) | B1 | | Any one stated or used |
| | $P\left(\hat{P} > 0.529 \mid B(500, 0.55)\right)$ = | M1 | | Use of B(500, 0.55)<br>M0 for use of 0.529 or 0.5 |
| | $P\left(Z > \dfrac{0.529 - 0.55}{\sqrt{\frac{0.55 \times 0.45}{500}}}\right)$ = P($Z$ > – **0.94**) | M1<br>A1 | | Accept use of 0.529 in denominator giving $z$ = 0.94075 but not use of 0.5<br>Ignore inequality and sign<br>AWRT (0.94388) |
| | = **0.82 to 0.83** | A1 | 5 | AWFW (0.82738) |
| | **Total** | | **15** | |
| | **TOTAL** | | **75** | |