### Q1, (Jun 2008, Q4)

\[ H_0: m_M = m_A \], \ H_1: m_M \neq m_A \]
- "average"
  \[ R_M = 40, \ m(m+n+1) - R_M = 72 \]
  \[ W = 40 \]
  \[ CR: W \leq 38 \]


#### B1
- Both hypotheses, AEF. Not Both found A0 if no or wrong 72
- Or equivalent In context. B1 if no M1 but conclusion correct Allow average here.

### Q2, (Jun 2010, Q5)

#### (i)
Assumes salaries symmetrically distributed
- \( H_0: m(\text{median}) = 19.5, \ H_1: m(\text{median}) \neq 19.5 \)
- \( P = 867 \) (or 408)
- Using normal approximation
- \( \mu = \frac{1}{4} \times 50 \times 51 = 637.5 \)
- \( \sigma^2 = 50 \times 51 \times 101/24 = 10731.25 \)
- \( z = (a - 637.5)/\sqrt{10731.25} \)
- Use \( a = 866.5 \)
- \( = 2.211, \) or 2.215 or 2.220 (– from 408)
- Compare their \( z \) with 1.96 and reject \( H_0 \)


#### B1
- In context
- For both ; not \( \mu \); accept words
- \( a=866.5, \) 867, 867.5 (or 408.5, 408, 407.5)
- Or \( p \)-value rounding to 0.026 or 0.027
- Compare with 0.05 or equivalent
- \( z \)
- Or find critical region

#### (ii)
Use sign test when salary distribution is skewed


#### B1
- 1

### Q3, (Jun 2011, Q5)

#### (i)
Does not require a known probability distribution

#### (ii)
\( H_0: m_A = m_B, \ H_1: m_A \neq m_B \)
- Ranks: A 1 2 3 5 6 10
  - B 4 7 8 9 11 12
- \( R_A = 27, 78 - 27 = 51, \) so \( W = 27 \)
- OR: \( R_B = 51, 78 - 51 = 27 \)
- 5% CV = 26
- \( 27 > CV \) so do not reject \( H_0 \)


#### B1
- Medians
- Use \( N(39.39) \) with cc B1
- \( P(W \leq 27.5), Z=-1.84 \) or equivalent M1
- Not in CR etc A1

#### (iii)
\( B \) would have an extra rank 13
- W still 27 but CV now 27
- \( H_0 \) is now rejected


#### A1
- 7
- In CR Ho rejected A1
### Q4, (Jun 2014, Q6)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>(i)</td>
<td>1 + 2 + ... + 11 = 66</td>
<td>M1</td>
<td>M0 if followed by incorrect work.</td>
</tr>
<tr>
<td>(ii)</td>
<td>((N) \frac{(132.264)}{(W + 0.5 - &quot;132&quot;)} \sqrt{\text{264}})</td>
<td>B1</td>
<td>Allow reversed if consistent OR (132(-0.5)\pm2\times\sqrt{264})</td>
</tr>
<tr>
<td></td>
<td>(&lt;-) 2.576</td>
<td>M1</td>
<td>Allow wrong, or no, oe.</td>
</tr>
<tr>
<td></td>
<td>Solve inequality (&lt; 89.6) ((66 \leq W \leq 89))</td>
<td>M1*</td>
<td>May be earned later.</td>
</tr>
<tr>
<td></td>
<td>*M1</td>
<td>B1</td>
<td>Allow 2.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A1</td>
<td>or equation if final answer uses &lt; or (\leq) Integer needed.</td>
</tr>
</tbody>
</table>

### Q5, (Jun 2012, Q3i)

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Populations have identical/same distributions (apart from location) ((H_0: m_1 = m_2, H_1: m_1 \neq m_2))</td>
<td>B1</td>
<td>Allow ‘Data quantitative’</td>
</tr>
<tr>
<td></td>
<td>Ranks 1 2 4 6 9 10 5 7 8 11 12 13</td>
<td>M1</td>
<td>Can be implied.</td>
</tr>
<tr>
<td></td>
<td>(R_m = 32, m(m + n + 1) - R_m = 52)</td>
<td>A1</td>
<td>M1A0 possible</td>
</tr>
<tr>
<td></td>
<td>(W = 32)</td>
<td>A1</td>
<td>M1A0 possible</td>
</tr>
<tr>
<td></td>
<td>Critical value = 29</td>
<td>B1</td>
<td>Correct first conclusion ft TS and CV</td>
</tr>
<tr>
<td></td>
<td>32 &gt; 29, do not reject (H)</td>
<td>M1</td>
<td>ft TS only.</td>
</tr>
<tr>
<td></td>
<td>There is insufficient evidence at the 10% significance level of a difference between the median marks of the two groups. oe.</td>
<td>A1</td>
<td></td>
</tr>
</tbody>
</table>
| (i)          | Distribution of heights may not be normal/is unknown | B1          | Allow “No assumption required”, but nothing else  
|             |                                               | [I]         | Not “groups independent” unless something else as well |
| (ii)        | $H_0: m_A = m_B, H_1: m_A \neq m_B$               | B1          | Medians. Allow words in context. Not $\mu$ unless “median” stated |
|             | Ranks:                                            | B1          | allow $\frac{1}{2} \times 11 \times (11+11+1)$ |
|             | A: 4, 8, 10, 11, 14, 15, 16, 18, 20, 21, 22      | B1          | allow $\frac{1}{12} \times 11 \times 11 \times (11+11+1)$ |
|             | B: 1, 2, 3, 5, 6, 7, 9, 12, 13, 17, 19           | B1          | Standardising. Allow no/incorrect cc. |
|             | $m = n = 11, R_m = 159$ or 94                     | M1          | Value |
|             | Use normal approximation with mean 126.5 $[= 253/2]$ | B1          | ft. TS |
|             | Variance 231.92 $[= 2783/12]$                    | M1          | ft. TS |
| (a)         | $P(\leq 94) = \Phi((94.5 - 126.5)/\sqrt{231.92}))$ | M1          | Standardising; value |
|             | or $P(\geq 159) = 0.0178$                       | M1          | ft. TS |
|             | $\leq 0.025$ and reject $H_0$                    | M1A1        | Or equivalent in context. ft. TS. |
| (b)         | $z = (94.5 - 126.5)/\sqrt{231.92} = -2.101$     | M1          | |
|             | $<-1.96$ so reject $H_0$                         | M1          | |
|             | There is evidence that salinity affects growth   | A1          | |

Q7, (Jun 2015, Q6)
### Q8, (Jun 2016, Q2)

<table>
<thead>
<tr>
<th>H₀: The samples are drawn from identical popns.</th>
<th>B1</th>
<th>Allow m₁=m₂ ; m₁≠m₂</th>
<th>Critical region method. First B₁B₁B₁ as main scheme $x \pm 0.5 = 188.5 \sqrt{471.25}$ or $&lt; -1.96$ M₁A₁B₁ $x &lt; 146$ A₁ 135 is in CR, rej H₀ M₁ Conclusion A₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁: The samples are from different popns.</td>
<td>B₁</td>
<td>Allow 13x29/2</td>
<td></td>
</tr>
<tr>
<td>Mean=188.5</td>
<td></td>
<td>Allow 13x15x29/12</td>
<td></td>
</tr>
<tr>
<td>Var=471.25</td>
<td>B₁</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$135 + 0.5 - &quot;188.5&quot;$</td>
<td>M₁</td>
<td>Allow M₁A₁₀ for missing or incorrect c.c.</td>
<td></td>
</tr>
<tr>
<td>$\sqrt{471.25}$</td>
<td>ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2.44</td>
<td>A₁</td>
<td>Allow -2.46 no c.c., -2.49 wrong c.c.</td>
<td></td>
</tr>
<tr>
<td>CV=-1.96</td>
<td>B₁</td>
<td>Ft both TS,CV</td>
<td>0.0073 (or 0.0069 or 0.0064) B₁ pft&lt; 2.5% (allow 5% for M₁), rej H₀</td>
</tr>
<tr>
<td>TS&lt;CV, reject H₀</td>
<td>M₁</td>
<td>Not over-assertive. Cwo, allow from -2.46 or -2.49</td>
<td></td>
</tr>
<tr>
<td>Sufficient evidence that the samples were drawn from different populations.</td>
<td>A₁</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Q8, (Jun 2016, Q2)

<table>
<thead>
<tr>
<th>H₀: $m_A = m_B$, H₁: $m_B &lt; m_A$</th>
<th>B1</th>
<th>M1</th>
<th>For both. Allow any sensible hypotheses.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempt ranks</td>
<td></td>
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</tr>
<tr>
<td>15, 1, 6, 12, 11, 13, 14; 7, 9, 3, 10, 8, 2, 5, 4</td>
<td>A1</td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>$R_m = 72$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$W = 40$</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>$CV = 41$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“40” &lt; 41 reject H₀</td>
<td>M₁</td>
<td>A₁</td>
<td></td>
</tr>
<tr>
<td>Evidence that treatment $B$ is more effective.</td>
<td>A₁</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| [9]                              | B1 | M1 |                                         |

| [8]                              |    |    |                                        |