|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress descriptor |
| **1a** | Two from:   * Each bolt is either faulty or not faulty. * The probability of a bolt being faulty (or not) may be assumed constant. * Whether one bolt is faulty (or not) may be assumed to be independent (or does not affect the probability of) whether another bolt is faulty (or not). * There is a fixed number (50) of bolts. * A random sample. | **B2** | 1.2  1.2 | 5th  Understand the binomial distribution (and its notation) and its use as a model. | |
|  | **(2)** |  |  | |
| **1b** | Let *X* represent the number of faulty bolts.  *X*~B(50, 0.25)  P(*X* ⩽ 6) = 0.0194  P(*X* ⩽ 7) = 0.0453  P(*X* ⩾ 19) = 0.0287  P(*X* ⩾ 20) = 0.0139 | **M1**  **M1dep** | 3.4  1.1b | 5th  Find critical values and critical regions for a binomial distribution. |
| Critical Region is *X* ⩽ 6 ∪ *X* ⩾ 20 | **A2** | 1.1b  1.1b |
|  | **(4)** |  |  |
| (6 marks) | | | | |
| Notes  1a  Each comment must be in context for its mark. | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress descriptor |
| **2a** | The set of **values** of the test statistic for which the **null**  **hypothesis is rejected** in a hypothesis test. | **B2** | 1.2  1.2 | 5th  Understand the language of hypothesis testing. |
|  | **(2)** |  |  |
| **2b** | P(*X* ⩾ 15) = 1− 0.9831 = 0.0169  P (X ⩾ 16) = 1 – 09936 = 0.0064 | **M1** | 1.1b | 5th  Find critical values and critical regions for a binomial distribution. |
| Critical region is 16 ⩽ *X* (⩽ 30) | **A1** | 1.1b |
| Probability of rejection is 0.0064 | **A1** | 1.1b |
|  | **(3)** |  |  |
| **2c** | Not in critical region therefore insufficient evidence to reject H0. | **B1** | 2.2b | 6th  Interpret the results of a binomial distribution test in context. |
| There is insufficient evidence at the 1% level to suggest that the value of *p* is bigger than 0.3. | **B1** | 3.2a |
|  | **(2)** |  |  |
| (7 marks) | | | | |
| Notes  **2c**  Conclusion must be in context (i.e. use *p*), mention the significance level and be non-assertive. | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Q** | **Scheme** | **Marks** | **AOs** | **Pearson Progression Step and Progress descriptor** |
| **3a** | P(*X* ⩽ 1) = 0.0076 and P (*X* ⩽ 2) = 0.0355 | **M1** | 1.1b | 5th  Find critical values and critical regions for a binomial distribution. |
| P(*X* ⩾ 10) = 1 – 0.9520 = 0.0480 and  P(*X* ⩾ 11) = 1 – 0.9829 = 0.0171 | **A1** | 1.1b |
| Critical region is *X* ⩽ 1 ∪ 11 ⩽ *X* (⩽ 20) | **A1** | 1.1b |
|  | **(3)** |  |  |
| **3b** | Significance level = 0.0076 + 0.0171  = 0.0247 or 2.47% | **B1** | 1.1b | 6th  Calculate actual significance levels for a binomial distribution test. |
|  | **(1)** |  |  |
| **3c** | Not in critical region therefore insufficient evidence to reject H0. | **B1** | 2.2b | 6th  Interpret the results of a binomial distribution test in context. |
| There is insufficient evidence at the 5% level to suggest that the value of *p* is not 0.3. | **B1** | 3.2a |
|  | **(2)** |  |  |
| (**6 marks**) | | | | |
| **Notes**  **3c**  Conclusion must contain context and non-assertive for first B1. | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Q** | **Scheme** | **Marks** | **AOs** | **Pearson Progression Step and Progress descriptor** |
| **4a** | *X*~B(28, 0.37) | **M1** | 3.4 | 5th  Find critical values and critical regions for a binomial distribution |
| P(*X* ⩾ 15) = 1 – 0.9454 = 0.0546 and  P(*X* ⩾ 16) = 1 – 0.9762 = 0.0238 | **M1dep** | 1.1b |
| Critical region is *X* ⩾ 16 | **A1** | 1.1b |
|  | **(3)** |  |  |
| **4b** | In critical region therefore sufficient evidence to reject H0 | **B1** | 2.2b | 6th  Interpret the results of a binomial distribution test in context. |
| There is sufficient evidence at the 5% level to suggest that the value of *p* is bigger than 0.37. | **B1** | 3.2a |
|  | **(2)** |  |  |
| (**5 marks**) | | | | |
| **Notes**  **4a**  First M1 for correct distribution seen or implied. Second M1 (dependent on first) for evidence that correct probabilities for either critical value examined.  **4b**  Conclusion must contain context and non-assertive for first B1. | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Q** | **Scheme** | **Marks** | **AOs** | **Pearson Progression Step and Progress descriptor** |
| **5a** | H0: *p* = 0.2  H1: *p* > 0.2 | **B1** | 2.5 | 5th  Carry out 1-tail tests for the binomial distribution. |
| Let *X* represent the number of times the taxi is late.  *X*~B(5, 0.2) seen or implied. | **M1** | 3.3 |
| Either  P(*X* ⩾ 3) = 1 – P(*X* ⩽ 2) = 1 – 0.9421  = 0.0579  0.0579 > 0.05  There is insufficient evidence at the 5% significance level that there is an increase in the number of times **the taxi/driver is late**.  Or  P(*X* ⩾ 3) = 1 – P(*X* ⩽ 2) = 0.0579  P(*X* ⩾ 4) = 1 – P(*X* ⩽ 3) = 0.0067  So critical region is *X* ⩾ 4  3 < 4 or 3 is not in the critical region  So there is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late. | **M1**  **A1**  **B1**  **B1**  **M1**  **A1**  **B1**  **B1** | 1.1b  1.1b  1.1b  3.2a  1.1b  1.1b  1.1b  3.2a |
|  | **(6)** |  |  |
| **5b** | Two sensible reasons. For example,   * Different time of the day Linda travels to work. * More traffic on different days (e.g. Monday morning, Friday afternoon). * Weather conditions. * Road works. | **B2** | 2.2b  2.2b | 5th  Understand the binomial distribution (and its notation) and its use as a model. |
|  | **(2)** |  |  |
| **(8 marks)** | | | | |
| **Notes**  Conclusion must be non-assertive. | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Q** | **Scheme** | **Marks** | **AOs** | **Pearson Progression Step and Progress descriptor** |
| **6a** | Let *X* represent the number of bowls with minor defects (seen or implied).  *X*B(25, 0.2) may be implied  P(*X* ⩽ l) = 0.0274  P(*X* = 0) = 0.0038  P*(X* ⩽ 8) = 0.9532  P(*X* ⩾ 9) = 0.0468  P(*X* ⩽ 9) = 0.9827  P(*X* ⩾ 10) = 0.0173  Critical region is *X* = 0 ∪ *X* ⩾ 10 | **M1**  **M1dep**  **A1**  **M1**  **A2** | 3.4  1.1b  1.1b  1.1b  1.1b 1.1b | 5th  Find critical values and critical regions for a binomial distribution. |
|  | **(6)** |  |  |
| **6b** | Significance level = 0.0038 + 0.0173  = 0.0211 or 2.11% | **B1** | 1.2 | 6th  Calculate actual significance levels for a binomial distribution test. |
|  | **(1)** |  |  |
| **6c** | H0: *p* = 0.2; H1: *p* < 0.2 | **B1** | 2.5 | 5th  Carry out 1-tail tests for the binomial distribution. |
| Let *Y* represent number of bowls with minor defects  (Under H0) *Y*~B(20, 0.2) (may be implied) | **M1** | 3.4 |
| Either  P(*Y* ⩽ 2) = 0.2061  0.2061 > 0.1 (or 10%)  Insufficient evidence at the 10% level to suggest that the proportion of defective bowls has decreased.  Or  P(*Y* ⩽ 2) = 0.2061  P(*Y* ⩽ 1) = 0.0692 so critical region is *Y* ⩽ 1  Insufficient evidence at the 10% level to suggest that the proportion of defective bowls has decreased.  0.2061 > 0.10 or 0.7939 < 0.9 | **B1**  **M1**  **A1**  **B1**  **M1**  **A1** | 1.1b  1.1b  3.2b  1.1b  1.1b  3.2a |
|  | **(5)** |  |  |
| **(12 marks)** | | | | |
| **Notes**  **6a**  M1 for examining probabilities for on both sides for either critical value, A1 for each correct pair.  **6c**  Conclusion must be non-assertive. | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Q** | **Scheme** | **Marks** | **AOs** | **Pearson Progression Step and Progress descriptor** |
| **7** | H0: *p* = 0.25, H1: *p*> 0.25 | **B1** | 2.5 | 5th  Carry out 1-tail tests for the binomial distribution. |
| Let *X* represent the number of seeds that germinate.  (Under H0) *X*~B(25, 0.25) | **M1** | 3.4 |
| P(*X* ⩾ 10) = 1 – P(*X* ⩽ 9) = 0.0713 | **M1** | 1.1b |
| > 0.05 | **A1** | 1.1b |
| 10 is not in critical region therefore insufficient evidence to reject H0. | **B1** | 2.2b |
| There is insufficient evidence at the 5% level to suggest that the book has underestimated the probability. (o.e.) | **B1** | 3.2a |
| **(6 marks)** | | | | |
| **Notes** | | | | |