|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **1a** | The sample mean… | **B1** | 1.2 | 4th  Be able to quote the central limit theorem |
| …is (approximately) normally distributed with mean *μ* and variance | **B1** | 1.2 |
|  | **(2)** |  |  |
| **1b** | The sample must be random | **B1** | 1.2 | 5th  Know the conditions for the use of the central limit theorem |
|  | **(1)** |  |  |
| (3 marks) | | | | |
| Notes  **1a** **B1** must state *sample* mean (accept )  **B1** parameters must be given. Accept standard deviation rather than variance  **1b** **B1** for sample is random | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **2a** |  | **M1** | 3.1a | 7th  Apply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.1469 | **A1** | 1.1b |
|  | **(3)** |  |  |
| **2b** | No: The population is normally distributed so the sample mean is also normally distributed. | **B1** | 2.4 | 5th  Know the conditions for the use of the central limit theorem |
|  | **(1)** |  |  |
| (4 marks) | | | | |
| Notes  **2a** **M1** for attempt to find distribution of  using given parameters, must divide by 10  **M1** for attempt to find  **A1** awrt 0.147  **2b** **B1** for ‘No’ with correct reason | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **3a** |  | **M1** | 3.1a | 7th  Apply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.0268 | **A1** | 1.1b |
|  | **(3)** |  |  |
| **3b** | Require | **M1** | 3.1a | 8th  Recognise and apply the central limit theorem in contextualised situations |
| *Z* = (–)2.3263 | **B1** | 1.1a |
|  | **M1** | 1.1b |
|  | **M1** | 1.1b |
| *n* = 73 | **A1** | 3.2a |
|  | **(5)** |  |  |
| (8 marks) | | | | |
| Notes  **3a** **M1** for attempt to find distribution of  using given parameters, must divide by 50  **M1** for attempt to find  **A1** awrt 0.027  **3b** **M1** for probability statement in terms of *Z* and using  **B1** for correct *Z* value (from tables); accept + or – here  **M1** for attempt to solve resulting equation using *their* *Z* ( must now be –)  **M1** for value for  leading to value for *n*  **A1ft** *their Z*  value if all M marks awarded (answer must be an integer) | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **4a** | 0.1 + *k* + 2*k* + 0.3 + 0.24 = 1 | **M1** | 1.1b | 1st  Understand how to find unknowns from a probability mass function |
| Hence *k* = 0.12 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4bi** | E(*X*) = 1 × 0.1 + 2 × 0.12 + 4 × 0.24 + 5 × 0.3 + 6 × 0.24 | **M1** | 1.1b | 2nd  Calculate the mean of a discrete random variable |
| = 4.24 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4bii** | Var(*X*) = 12 × 0.1 + … + 62 × 0.24 – 4.242 | **M1** | 1.1b | 3rd  Calculate the variance of a discrete random variable |
| = 2.5824 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4c** | CLT states that the sample mean is approximately normally distributed. | **B1** | 1.2 | 6th  Recognise when the central limit theorem is required |
|  | **(1)** |  |  |
| **4d** |  | **M1** | 3.1a | 7th  Apply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.9265 | **A1** | 1.1b |
|  | **(3)** |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **4e** | Estimate is fairly accurate since *n* is large. | **B1** | 2.4 | 5th  Know the conditions for the use of the central limit theorem |
|  | **(1)** |  |  |
| (11 marks) | | | | |
| Notes  **4a** **M1** for attempt to add probabilities and equate to 1  **A1** cao  **4bi** **M1A1ft** from *their* *k*  **4bii** **M1A1ft** from *their k*  **4c** **B1** for completely correct reason  **4d** **M1** for attempt to find distribution of  using calculated parameters, must divide by 80  **M1** for attempt to find  **A1ft** awrt 0.927 (ft *their* **4bi** and **4bii**)  **4e** **B1** for correct statement including *n* is large | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **5** |  | **M1**  **A1** | 3.1a  1.1b | 7th  Apply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.3300 | **A1** | 1.1b |
| (4 marks) | | | | |
| Notes  1st **M1** for use of CLT with given Poisson parameters  1st **A1** for completely correct normal distribution  2nd **M1** for attempt to find  using *their* normal distribution  2nd **A1** awrt 0.33 | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **6a** | Mean: | **B1** | 1.1b | 6th  Calculate the mean/variance of a geometric distribution |
| Variance: | **B1** | 1.1b |
|  | **(2)** |  |  |
| **6b** |  | **M1**  **A1** | 3.1a  1.1b | 7th  Apply the central limit theorem to a range of probability distributions |
|  | **M1** | 1.1b |
| = 0.1587 | **A1** | 1.1b |
|  | **(4)** |  |  |
| (6 marks) | | | | |
| Notes  **6a** **B1** for correct mean  **B1** for correct variance  **6b** 1st **M1** for use of CLT with *their* Geo parameters  1st **A1** for completely correct normal distribution  2nd **M1** for attempt to find  using *their* normal distribution  2nd **A1** awrt 0.159 | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **7** | Model is Negative B(8, 0.3) | **B1** | 3.3 | 8th  Recognise and apply the central llimit theorem in contextualised situations |
|  | **B1** | 1.1b |
|  | **B1** | 1.1b |
|  | **M1**  **A1** | 3.1a  1.1b |
|  | **M1** | 1.1b |
| = 0.145 | **A1** | 2.1 |
| (7 marks) | | | | |
| Notes  **B1** for correct model  **B1** for correct expectation  **B1** for correct variance  1st **M1** for use of CLT with *their* Negative B parameters  1st **A1** for completely correct normal distribution  2nd **M1** for attempt to find  using *their* normal distribution  2nd **A1** cao | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **8a** |  | **M1** | 3.1b | 7th  Apply the central limit theorem to a range of probability distributions |
| = 0.007 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **8b** | The population is normally distributed. | **B1** | 2.4 | 5th  Know the conditions for the use of the central limit theorem |
|  | **(1)** |  |  |
| **8c** | Model is B(24, 0.2) | **B1** | 3.1b | 8th  Recognise and apply the central llimit theorem in contextualised situations |
| Mean: 24 × 0.2 = 4.8  Variance: 4.8 × 0.8 = 3.84 | **B1** | 1.1b |
|  | **M1** | 1.1b |
| = 0.057 | **A1** | 2.1 |
|  | **(4)** |  |  |
| (7 marks) | | | | |
| Notes  **8a** **M1** for attempt to find  **A1** awrt 0.007  **8b** **B1** must state normally distributed  **8c** **B1** correct model  **B1** mean and variance both correct  **M1** for attempt to find  using *their* model and mean/variance  **A1** cao | | | | |