|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **1ai** | Let *X* denote the number of attempts needed to pass:  *X* ~ Geo(0.35)  P(*X* = 4) = 0.35 × 0.653 | **M1** | 3.3 | 5th  Use the geometric distribution to model real-world situations |
| = 0.0961 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **1aii** | P(*X* ⩾ 5) = 0.654 | **M1** | 1.1b | 5th  Use the geometric distribution to model real-world situations |
| = 0.1785 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **1b** | The attempts are independent | **B1** | 3.5b | 5th  Understand the assumptions necessary for the geometric distribution |
| The probability of passing remains the same on each attempt. | **B1** | 3.5b |
|  | **(2)** |  |  |
| (6 marks) | | | | |
| Notes  **1ai** **M1** for use of *p*(1 – *p*)*x* – 1  **A1** for 0.0961  **1aii** **M1** for (1 – *p*)*x* – 1  **A1** for awrt 0.179  **1b** **B1** for attempts are **independent**  **B1** for **probability of passing remains the same on each attempt** (oe) | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **2a** | *X* ~ Geo(0.2) | **B1** | 2.5 | 5th  Use the geometric distribution to model real-world situations |
|  |  | **(1)** |  |  |
| **2bi** | P(*X* = 3) = 0.2 × 0.82 | **M1** | 1.1b | 5th  Use the geometric distribution to model real-world situations |
|  | = 0.128 | **A1** | 1.1b |  |
|  |  | **(2)** |  |  |
| **2bii** |  | **M1** | 1.1b | 6th  Calculate the mean of a geometric distribution |
|  | = 5 | **A1** | 1.1b |  |
|  |  | **(2)** |  |  |
| **2c** |  | **M1** | 1.1b | 6th  Calculate the variance of a geometric distribution |
|  | = 20 | **A1** | 2.1 |  |
|  |  | **(2)** |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **2d** | P(*X* = 3) × P(*X* = 3) | **M1** | 3.1 | 7th  Solve problems using the geometric distribution in a range of contexts |
| = 0.1282 = 0.0164 | **A1** | 1.1b |
|  | **(2)** |  |  |
| (9 marks) | | | | |
| Notes  **2a** **B1** for Geo(0.2)  **2bi** **M1** for use of *p*(1 – *p*)*x* – 1  **A1** for 0.128  **2bii** **M1** for  **A1**: For 5 (cao)  **2c** **M1** for  **A1** cso  **2d** **M1A1ft** *their* **2bi** | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **3a** | *Y* ~ Negative B(6, 0.7) | **B1**  **B1** | 3.3  2.5 | 4th  Understand the basics of the negative binomial distribution |
|  | **(2)** |  |  |
| **3b** | The attempts are independent. | **B1** | 3.5b | 5th  Understand the assumptions necessary for the negative binomial distribution |
| The probability of hitting the bullseye remains the same on each attempt. | **B1** | 3.5b |
|  | **(2)** |  |  |
| **3ci** |  | **M1** | 1.1b | 5th  Use the negative binomial distribution to model real-world situations |
| = 0.1779 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **3cii** | This requires finding the probability that she takes eight attempts to get five more bullseyes so new model:  (Z ~) Negative B(5, 0.7) | **M1** | 3.3 | 8th  Solve problems using the negative binomial distribution in a range of contexts |
|  | **M1** | 1.1b |
| = 0.1588 | **A1** | 1.1b |
|  | **(3)** |  |  |
| (9 marks) | | | | |

|  |
| --- |
| Notes  **3a** **B1** for ‘Negative B’ and **B1** for both parameters correct and in correct format  **3b** **B1** for the attempts are **independent**  **B1** for **the probability of hitting the bullseye remains the same on each attempt** (oe)  **3ci** **M1** for use of correct formula (ft *their* model parameters if Negative B)  **A1** awrt 0.178  **3cii** **M1** for new model, may be implied by subsequent working (ft *their* **3a** if Negative B)  **M1** for use of correct formula with new model  **A1** awrt 0.159 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **4a** | *X* ~ Negative B(5, 0.6) | **B1** | 3.3 | 4th  Understand the basics of the negative binomial distribution |
| Attempts are independent/probability remains the same for each attempt. | **B1** | 3.5b |
|  | **(2)** |  |  |
| **4b** |  | **M1** | 1.1b | 5th  Use the negative binomial distribution to model real-world situations |
| =0.1003 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4c** |  | **M1** | 1.1b | 6th  Calculate the mean of a negative binomial distribution |
|  | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4d** |  | **M1** | 1.1b | 7th  Calculate the variance of a negative binomial distribution |
|  | **A1** | 2.1 |
|  | **(2)** |  |  |
| (8 marks) | | | | |

|  |
| --- |
| Notes  **4a** **B1** for ‘Negative B’ (parameters *not* required)  **B1** for one correct reason  **4b** **M1** for use of correct formula  **A1** awrt 0.100  **4c** **M1** for use of correct formula  **A1**accept decimal equivalent (3 s.f. or better)  **4d** **M1** for use of correct formula  **A1** cso |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **5ai** |  | **B1** | 1.2 | 8th  Solve problems using the negative binomial distribution in a range of contexts |
|  | **M1** | 1.2 |
|  | **M1** | 1.1a |
| Hence *p* = 0.25 | **A1** | 1.1b |
| 0.25 × 200 = 50 | **A1** | 1.1b |
|  | **(5)** |  |  |
| **5aii** | *r* = 12 × 0.25 = 3 | **B1** | 1.1b | 6th  Calculate the mean of a negative binomial distribution |
|  | **(1)** |  |  |
| **5b** | The coins are different sizes and therefore can be distinquished by touch – the selection of coins is not really random. | **B1** | 2.3 | 5th  Understand the assumptions necessary for the negative binomial distribution |
|  | **(1)** |  |  |
| (7 marks) | | | | |
| Notes  **5ai** **B1** for expectation in terms of *r* and *p*  **M1** for variance in terms of *r* and *p* leading to…  **M1** for expression for *p* that can be solved  **A1** for *p*  **A1** for ’50’  **5aii** **B1** for *r*  **5b** **B1** for any suitable reason that questions the randomness of the selection | | | | |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **6a** | Model is Geo(0.55)  P(first hit on second go) = 0.55 × 0.45 | **M1** | 3.3 | 5th  Use the geometric distribution to model real-world situations |
| = 0.2475 | **A1** | 2.1 |
|  | **(2)** |  |  |
| **6bi** | Model is Negative B(4, 0.55) | **M1** | 1.1b | 5th  Use the negative binomial distribution to model real-world situations |
| =0.1668 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **6bii** | This requires finding the probability that he takes nine attempts to get six more hits.  Model is Negative B(6, 0.55) | **M1** | 3.3 | 8th  Solve problems using the negative binomial distribution in a range of contexts |
|  | **M1** | 1.1b |
| = 0.1413 | **A1** | 1.1b |
|  | **(3)** |  |  |
| **6c** |  | **B1** | 1.1b | 6th  Calculate the mean of a negative binomial distribution |
|  | **(1)** |  |  |
| **6d** |  | **M1** | 1.1b | 7th  Calculate the variance of a negative binomial distribution |
|  | **A1** | 2.1 |
|  | **(2)** |  |  |
| **6e** | Robbie might learn where the moles are and thus the probability of whacking each mole is unlikely to be constant (increase). | **B1** | 2.4 | 5th  Understand the assumptions necessary for the negative binomial distribution |
|  | **(1)** |  |  |
| (11 marks) | | | | |
| Notes  **6a** **M1** for use of Geo and correct formula  **A1** cso  **6bi** **M1** for use of Negative B and correct formula consistent with *their* parameters  **A1** awrt 0.167  **6bii** **M1** for new model, may be implied by subsequent working  **M1** for use of correct formula with *their* parameters – must be consistent  **A1** awrt 0.141  **6c** **B1** accept decimal equivalent  **6d** **M1** for use of correct formula with *their* model  **A1** cso  **6e** **B1** for any valid reason indicating that the probability of whacking each mole is unlikely to be constant (accept ‘change’ or ‘increase’) | | | | |