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| 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 | 5thUse the geometric distribution to model real-world situations |
| = 0.0961 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **1aii** | P(*X* ⩾ 5) = 0.654 | **M1** | 1.1b | 5thUse the geometric distribution to model real-world situations |
| = 0.1785 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **1b** | The attempts are independent | **B1** | 3.5b | 5thUnderstand 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) |

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

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| **2d** | P(*X* = 3) × P(*X* = 3) | **M1** | 3.1 | 7thSolve 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** |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **3a** | *Y* ~ Negative B(6, 0.7) | **B1****B1** | 3.32.5 | 4thUnderstand the basics of the negative binomial distribution |
|  | **(2)** |  |  |
| **3b** | The attempts are independent. | **B1** | 3.5b | 5thUnderstand 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 | 5thUse 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 | 8thSolve problems using the negative binomial distribution in a range of contexts |
|   | **M1** | 1.1b |
| = 0.1588 | **A1** | 1.1b |
|  | **(3)** |  |  |
| (9 marks) |

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| 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 |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **4a** | *X* ~ Negative B(5, 0.6) | **B1** | 3.3 | 4thUnderstand 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 | 5thUse the negative binomial distribution to model real-world situations |
| =0.1003 | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4c** |   | **M1** | 1.1b | 6thCalculate the mean of a negative binomial distribution |
|  | **A1** | 1.1b |
|  | **(2)** |  |  |
| **4d** |  | **M1** | 1.1b | 7thCalculate the variance of a negative binomial distribution |
|  | **A1** | 2.1 |
|  | **(2)** |  |  |
| (8 marks) |

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| 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 |

|  |  |  |  |  |
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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress Descriptor |
| **5ai** |   | **B1** | 1.2 | 8thSolve 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 | 6thCalculate 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 | 5thUnderstand 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 | 5thUse 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 | 5thUse 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 | 8thSolve problems using the negative binomial distribution in a range of contexts |
|  | **M1** | 1.1b |
| = 0.1413 | **A1** | 1.1b |
|  | **(3)** |  |  |
| **6c** |  | **B1** | 1.1b | 6thCalculate the mean of a negative binomial distribution |
|  | **(1)** |  |  |
| **6d** |   | **M1** | 1.1b | 7thCalculate 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 | 5thUnderstand 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’) |