# 4.8 Binomial distribution\_P\_2

**1a.** *[3 marks]*

## Markscheme

use of formula or Venn diagram      ***(M1)***

0.72 + 0.45 − 1       ***(A1)***

= 0.17       ***A1***

***[3 marks]***

**1b.** *[1 mark]*

## Markscheme

0.72 − 0.17 = 0.55      ***A1***

***[1 mark]***

**1c.** *[1 mark]*

## Markscheme

200 × 0.45 = 90      ***A1***

***[1 mark]***

**1d.** *[3 marks]*

## Markscheme

let *X* be the number of customers who order cake

*X* ~ B(200,0.45)        ***(M1)***

P(*X* > 100) = P(*X* ≥ 101)(= 1 − P(*X* ≤ 100))    ***(M1)***

= 0.0681      ***A1***

***[3 marks]***

**1e.** *[1 mark]*

## Markscheme

0.46 × 0.8 = 0.368    ***A1***

***[1 mark]***

**1f.** *[4 marks]*

## Markscheme

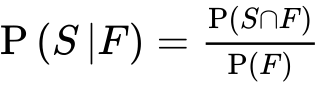
**METHOD 1**

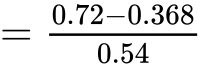
       ***M1A1A1***

**Note:** Award ***M1*** for an appropriate tree diagram. Award ***M1*** for LHS, ***M1*** for RHS.

     ***A1***

**METHOD 2**

       ***(M1)***

       ***A1A1***

**Note:** Award ***A1***for numerator, ***A1***for denominator.

     ***A1***

***[4 marks]***

**2a.** *[2 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

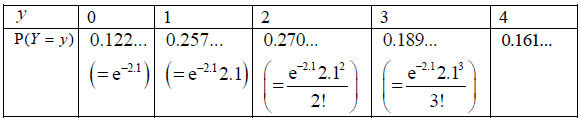


      ***(M1)A1***

***[2 marks]***

**2b.** *[4 marks]*

## Markscheme

      ***A1A1A1A1***

**Note:** Award ***A1*** for each correct probability for *Y* = 1, 2, 3, 4. Accept 0.162 for P(*Y* = 4).

***[4 marks]***

**2c.** *[3 marks]*

## Markscheme

      ***(M1)***

      ***(A1)***

      ***A1***

***[3 marks]***

**2d.** *[3 marks]*

## Markscheme

let  be the no of days per year that Steffi does not visit

      ***(M1)***

require       ***(M1)***



      ***A1***

***[3 marks]***

**2e.** *[4 marks]*

## Markscheme

**METHOD 1**

let  be the discrete random variable “number of times Steffi is not fed per day”

        ***M1***

      ***A1***

= 0.083979...      ***A1***

expected no of occasions per year > 0.083979... × 365 = 30.7      ***A1***

hence Steffi can expect not to be fed on at least 30 occasions       ***AG***

**Note:** Candidates may consider summing more than three terms in their calculation for .

**METHOD 2**

       ***M1A1***

0.0903… × 365       ***M1***

= 33.0 > 30      ***A1AG***

***[4 marks]***

**3a.** *[2 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

*X* ~ N(820, 2302)       ***(M1)***

**Note:** Award ***M1*** for an attempt to use normal distribution. Accept labelled normal graph.

⇒P(*X* > 1000) = 0.217       ***A1***

***[2 marks]***

**3b.** *[3 marks]*

## Markscheme

*Y* ~ B(24,0.217...)      ***(M1)***

**Note:** Award ***M1*** for recognition of binomial distribution with parameters.

P(*Y* ≤ 10) − P(*Y* ≤ 4)        ***(M1)***

**Note:** Award ***M1*** for an attempt to find P(5 ≤ *Y* ≤ 10) or P(*Y* ≤ 10) − P(*Y* ≤ 4).

= 0.613       ***A1***

***[3 marks]***

**4a.** *[2 marks]*

## Markscheme



    ***(M1)***

= 0.102     ***A1***

***[2 marks]***

**4b.** *[2 marks]*

## Markscheme

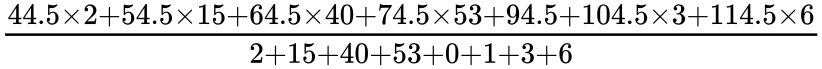
standard deviation =  (= 8.37)   ***(M1)A1***

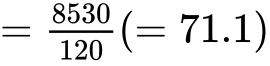
***[2 marks]***

**4c.** *[3 marks]*

## Markscheme

use of midpoints (accept consistent use of 45, 55 etc.)  ***(M1)***

   ***(M1)***

      ***A1***

**Note:** If 45, 55, etc. are used consistently instead of midpoints (implied by the answer 71.58…) award ***M1M1A0***.

***[3 marks]***

**4d.** *[2 marks]*

## Markscheme

13.9  ***(M1)A1***

***[2 marks]***

**4e.** *[1 mark]*

## Markscheme

valid reason given to include the examples below       ***R1***

variance is 192 which is not close to the mean (accept not equal to) standard deviation too high (using parts (a)(ii) and (b)(ii))

relative frequency of  ≤ 59 is 0.142 which is too high (using part (a)(i))

Poisson would give a frequency of roughly 14 for 80 ≤  ≤ 89

**Note:** Reasons which do not use values found in previous parts must be backed up with numerical evidence.

***[1 mark]***

**4f.** *[3 marks]*

## Markscheme



      ***(M1)***

attempt to solve a correct equation       ***(M1)***

*λ*= 20.1       ***A1***

***[3 marks]***

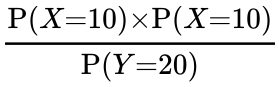
**4g.** *[5 marks]*

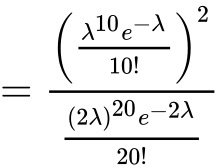
## Markscheme

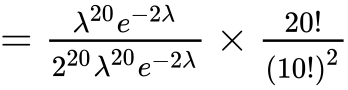
in 1 day, no of emails is *X* ~ Po(*λ*)

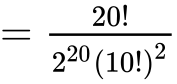
in 2 days, no of emails is *Y* ~ Po(2*λ*)       ***(A1)***

P(10 on first day | 20 in 2 days)        ***(M1)***

        ***(M1)***

     ***A1***

      ***A1***



which is independent of *λ*       ***AG***

***[5 marks]***

**5.** *[5 marks]*

## Markscheme

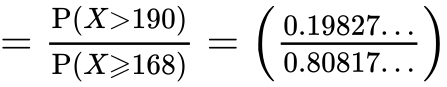
\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

*X* is number of squirrels in reserve  
*X* ∼ Po(179.2)      ***A1***

**Note:** Award ***A1*** if 179.2 or 56 × 3.2 seen or implicit in future calculations.

recognising conditional probability     ***M1***

P(*X* > 190 | *X* ≥ 168)

       ***(A1)(A1)***

= 0.245      ***A1***

***[5 marks]***

**6a.** *[2 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

*np* = 3.5      ***(A1)***

*p* ≤ 1 ⇒ least *n* = 4       ***A1***

***[2 marks]***

**6b.** *[5 marks]*

## Markscheme

(1 − *p*)*n* + *np*(1 − *p*)*n*−1 = 0.09478     ***M1A1***

attempt to solve above equation with *np* = 3.5     ***(M1)***

*n* = 12,  *p* =  (=0.292)     ***A1A1***

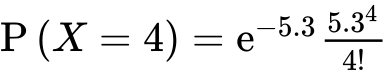
**Note:** Do not accept *n* as a decimal.

***[5 marks]***

**7a.** *[2 marks]*

## Markscheme



     ***(M1)***

= 0.164      ***A1***

***[2 marks]***

**7b.** *[2 marks]*

## Markscheme

**METHOD 1**

listing probabilities (table or graph)      ***M1***

mode *X* = 5 (with probability 0.174)     ***A1***

**Note:** Award ***M0A0*** for 5 (taxis) or mode = 5 with no justification.

**METHOD 2**

mode is the integer part of mean      ***R1***

E(*X*) = 5.3 ⇒ mode = 5      ***A1***

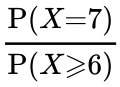
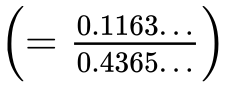
**Note:** Do not allow ***R0A1***.

***[2 marks]***

**7c.** *[3 marks]*

## Markscheme

attempt at conditional probability       ***(M1)***

 or equivalent       ***A1***

= 0.267      ***A1***

***[3 marks]***

**7d.** *[6 marks]*

## Markscheme

***METHOD 1***

the possible arrivals are (2,0), (1,1), (0,2)       ***(A1)***

     ***A1***

attempt to compute, using sum and product rule,      ***(M1)***

0.070106… × 0.52204… + 0.026455… × 0.33932… + 0.0049916… × 0.11028…      ***(A1)(A1)***

**Note:** Award ***A1***for one correct product and ***A1***for two other correct products.

= 0.0461       ***A1***

***[6 marks]***

**METHOD 2**

recognising a sum of 2 independent Poisson variables *eg Z* = *X* + *Y*      ***R1***



P(*Z* = 2) = 0.0461     ***(M1)A3***

***[6 marks]***

**8a.** *[2 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

let  be the number of bananas eaten in one day



     ***(M1)***

     ***A1***

***[2 marks]***

**8b.** *[4 marks]*

## Markscheme

**EITHER**

let  be the number of bananas eaten in one week

     ***(A1)***

     ***(A1)***

**OR**

let  be the number of days in one week at least one banana is eaten

     ***(A1)***

     ***(A1)***

**THEN**

     ***(M1)***

     ***A1***

***[4 marks]***

**9a.** *[3 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

     ***(M1)***

     ***(A1)***

     ***A1***

***[3 marks]***

**9b.** *[3 marks]*

## Markscheme

     ***(M1)(A1)***

     ***A1***

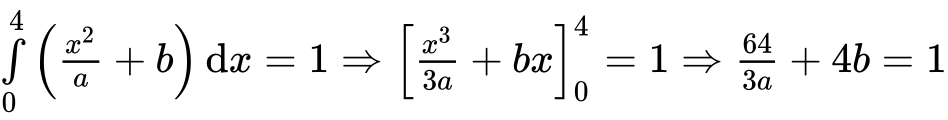
**Note:**     Award ***M1*** for clear recognition of binomial distribution.

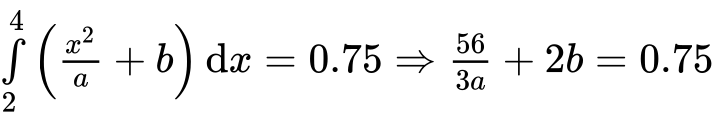
***[3 marks]***

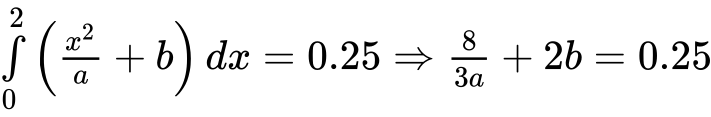
**10a.** *[5 marks]*

## Markscheme

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    ***M1A1***

    ***M1A1***

**Note:**     could be seen/used in place of either of the above equations.

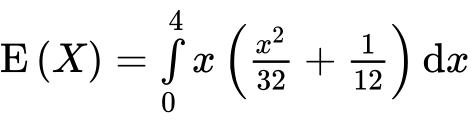
evidence of an attempt to solve simultaneously (or check given *a*,*b* values are consistent)     ***M1***

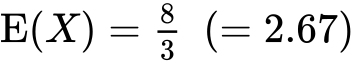
     ***AG***

***[5 marks]***

**10b.** *[2 marks]*

## Markscheme

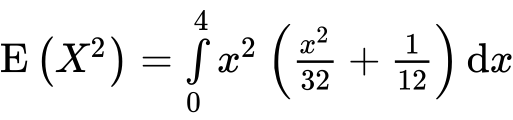
    ***(M1)***

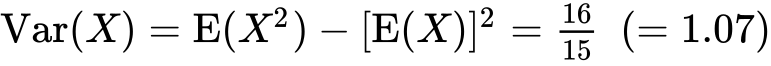
     ***A1***

***[2 marks]***

**10c.** *[2 marks]*

## Markscheme

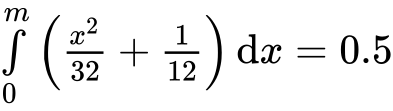
     ***(M1)***

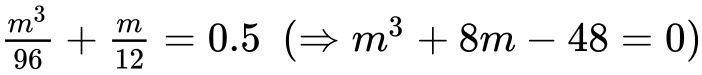
     ***A1***

***[2 marks]***

**10d.** *[3 marks]*

## Markscheme

    ***(M1)***

     ***(A1)***

     ***A1***

***[3 marks]***

**10e.** *[2 marks]*

## Markscheme

     ***(M1)***

     ***A1***

***[2 marks]***

**10f.** *[1 mark]*

## Markscheme

     ***A1***

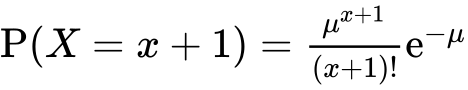
***[1 mark]***

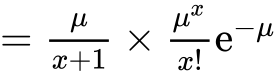
**11a.** *[3 marks]*

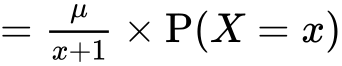
## Markscheme

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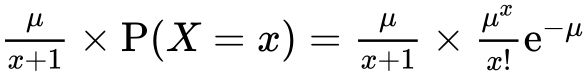
**METHOD 1**

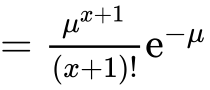
    ***A1***

    ***M1A1***

    ***AG***

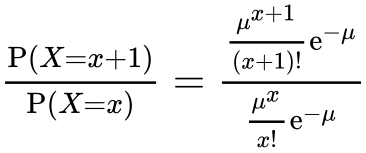
**METHOD 2**

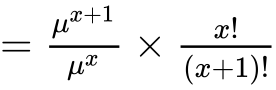
    ***A1***

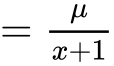
    ***M1A1***

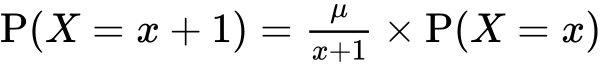
    ***AG***

**METHOD 3**

    ***(M1)***

    ***A1***

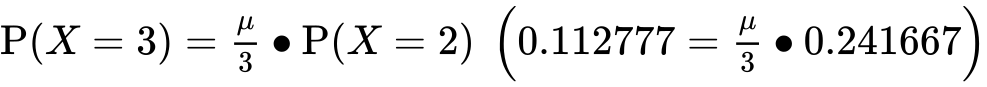
    ***A1***

and so      ***AG***

***[3 marks]***

**11b.** *[3 marks]*

## Markscheme

    ***A1***

attempting to solve for      ***(M1)***

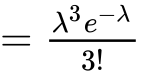
    ***A1***

***[3 marks]***

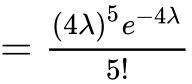
**12.** *[8 marks]*

## Markscheme

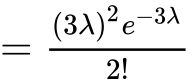
\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

P(3 in the first hour)      ***A1***

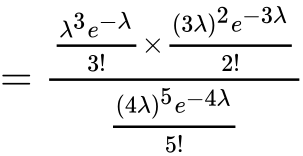
number to arrive in the four hours follows      ***M1***

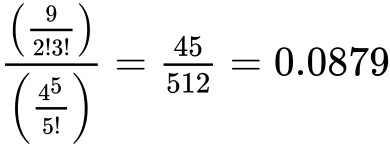
P(5 arrive in total)      ***A1***

attempt to find P(2 arrive in the next three hours)     ***M1***

     ***A1***

use of conditional probability formula     ***M1***

P(3 in the first hour given 5 in total)      ***A1***

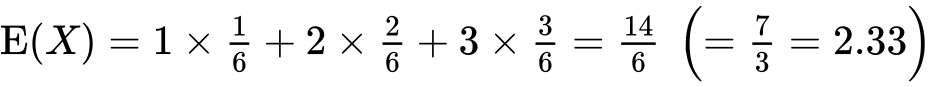
     ***A1***

***[8 marks]***

**13a.** *[2 marks]*

## Markscheme

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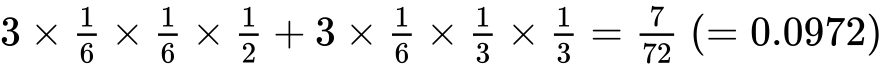
     ***(M1)A1***

***[2 marks]***

**13b.** *[3 marks]*

## Markscheme

     ***(M1)***

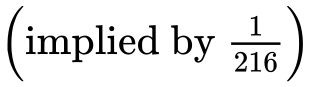
     ***A1***

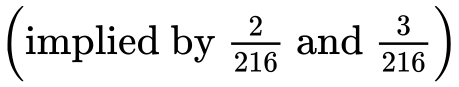
**Note:** Award ***M1*** for attempt to find at least four of the cases.

***[3 marks]***

**13c.** *[3 marks]*

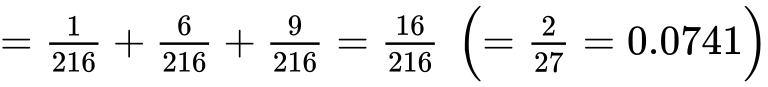
## Markscheme

recognising 111 as a possibility      ***(M1)***

recognising 112 and 113 as possibilities      ***(M1)***

seeing the three arrangements of 112 and 113     ***(M1)***

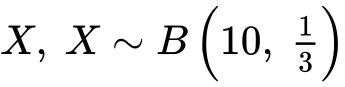


     ***A1***

***[3 marks]***

**13d.** *[3 marks]*

## Markscheme

let the number of twos be      ***(M1)***

     ***(M1)A1***

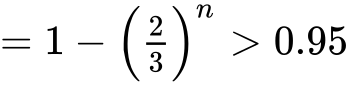
***[3 marks]***

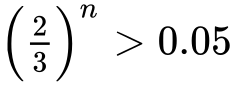
**13e.** *[3 marks]*

## Markscheme

let  be the number of balls drawn

     ***M1***

     ***M1***

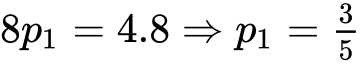


     ***A1***

***[3 marks]***

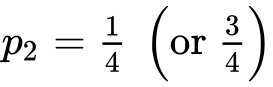
**13f.** *[8 marks]*

## Markscheme

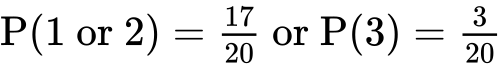
     ***(M1)A1***

     ***(M1)***

     ***(M1)***

     ***A1***

reject  as it gives a total greater than one

     ***(A1)***

recognising LCM as 20 so min total number is 20     ***(M1)***

the least possible number of 3’s is 3     ***A1***

***[8 marks]***

**14a.** *[3 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

    ***(A1)***

    ***(M1)A1***

***[3 marks]***

**14b.** *[3 marks]*

## Markscheme

    ***(A1)***

    ***(M1)***

the expected profit is $1.85 per glass sheet     ***A1***

***[3 marks]***

**14c.** *[2 marks]*

## Markscheme

    ***(M1)***

    ***A1***

***[2 marks]***

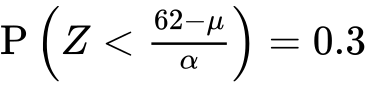
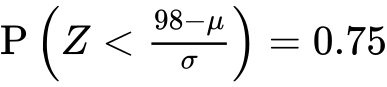
**15a.** *[6 marks]*

## Markscheme

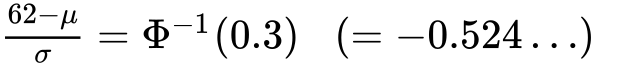
\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

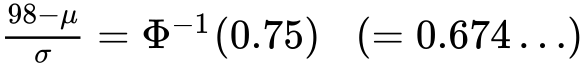
**Note:** In Section B, accept answers that correctly round to 2 sf.

(i)     let  be the weight of a worker and 

 and      ***(M1)***

**Note:** Award ***M1*** for a correctly shaded and labelled diagram.

and



or linear equivalents     ***A1A1***

**Note:** Condone equations containing the GDC inverse normal command.

(ii)     attempting to solve simultaneously     ***(M1)***

     ***A1A1***

***[6 marks]***

**15b.** *[1 mark]*

## Markscheme

**Note:** In Section B, accept answers that correctly round to 2 sf.

     ***A1***

***[1 mark]***

**15c.** *[2 marks]*

## Markscheme

**Note:** In Section B, accept answers that correctly round to 2 sf.

let  represent the number of workers over  kg in a lift of ten passengers

     ***(M1)***

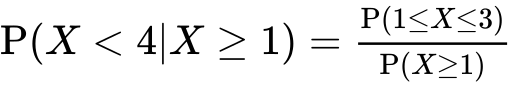
     ***A1***

***[2 marks]***

**15d.** *[3 marks]*

## Markscheme

**Note:** In Section B, accept answers that correctly round to 2 sf.

     ***M1(A1)***

**Note:** Award the ***M1*** for a clear indication of a conditional probability.

     ***A1***

***[3 marks]***

**15e.** *[3 marks]*

## Markscheme

**Note:** In Section B, accept answers that correctly round to 2 sf.

     ***(M1)***

     ***(M1)***

     ***A1***

***[3 marks]***

**15f.** *[3 marks]*

## Markscheme

**Note:** In Section B, accept answers that correctly round to 2 sf.

 workers require at least  elevators     ***(A1)***

     **(*M1)***

     ***A1***

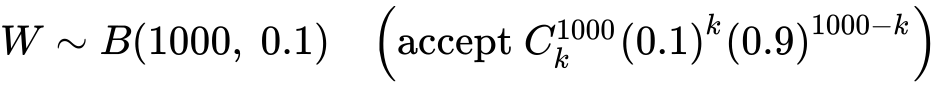
***[3 marks]***

***Total [18 marks]***

**16a.** *[2 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

     ***A1A1***

**Note:**     First ***A1*** is for recognizing the binomial, second ***A1*** for both parameters if stated explicitly in this part of the question.

***[2 marks]***

**16b.** *[1 mark]*

## Markscheme

     ***A1***

***[1 mark]***

**16c.** *[2 marks]*

## Markscheme

     ***(M1)***

     ***A1***

**Notes:** Award ***M0A0*** for 

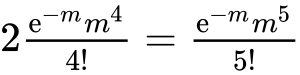
***[2 marks]***

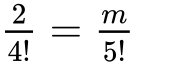
***Total [5 marks]***

**17a.** *[3 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

     ***M1A1***

or other simplification     ***M1***

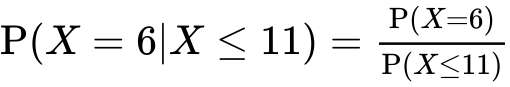
**Note:**     accept a labelled graph showing clearly the solution to the equation. Do not accept simple verification that  is a solution.

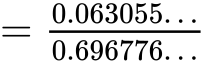
     ***AG***

***[3 marks]***

**17b.** *[4 marks]*

## Markscheme

     ***(M1) (A1)***

     ***(A1)***

     ***A1***

***[4 marks]***

***Total [7 marks]***

**18a.** *[6 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

(i)          ***(M1)A1***

**Note:**     Accept 

**Note:**     Award ***M1A0*** for  ()

(ii)          ***M1***

expected number of turnips      ***A1***

**Note:**     Accept .

(iii)     no of turnips weighing more than  is      ***M1***

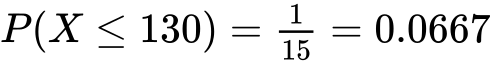
     ***A1***

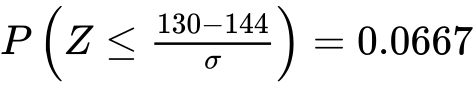
***[6 marks]***

**18b.** *[6 marks]*

## Markscheme

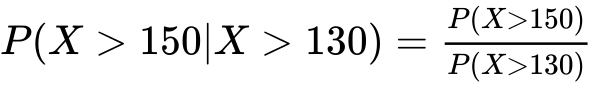
(i)     

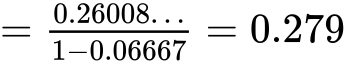
     ***(M1)***



     ***(A1)***

     ***A1***

(ii)          ***M1***

     ***A1***

expected number of turnips      ***A1***

***[6 marks]***

***Total [12 marks]***

**19a.** *[4 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

(i)     

     ***(M1)A1***

(ii)          ***M1***

     ***A1***

**Note:**     Accept “ day”.

***[4 marks]***

**19b.** *[3 marks]*

## Markscheme

     ***(A1)***

     ***(M1)A1***

***[3 marks]***

***Total [7 marks]***

**20a.** *[3 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

(i)          ***A1***

(ii)          ***(M1)***

     ***A1***

***[3 marks]***

**20b.** *[2 marks]*

## Markscheme

**EITHER**

using      ***(M1)***

**OR**

using      ***(M1)***

**THEN**

     ***A1***

***[2 marks]***

**20c.** *[3 marks]*

## Markscheme

 (most likely number of complaints received is zero)     ***A1***

**EITHER**

calculating  and      ***M1A1***

**OR**

sketching an appropriate (discrete) graph of  against      ***M1A1***

**OR**

finding  and stating that      ***M1A1***

**OR**

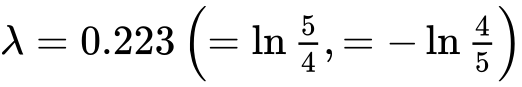
using  where      ***M1A1***

***[3 marks]***

**20d.** *[2 marks]*

## Markscheme

     ***(A1)***

     ***A1***

***[2 marks]***

***Total [10 marks]***

**21a.** *[2 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

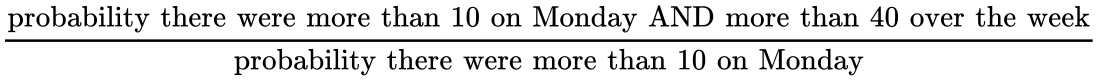
mean for week is 40.88     ***(A1)***

     ***A1***

***[2 marks]***

**21b.** *[5 marks]*

## Markscheme

     ***M1***

possibilities for the numerator are:

there were more than 40 birds on the power line on Monday     ***R1***

11 on Monday and more than 29 over the course of the next 6 days     ***R1***

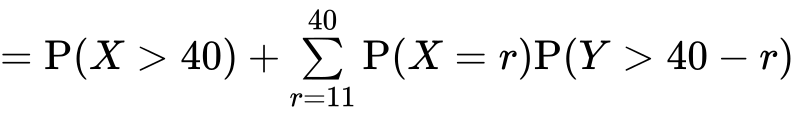
12 on Monday and more than 28 over the course of the next 6 days … until

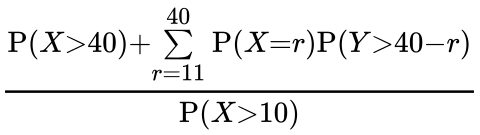
40 on Monday and more than 0 over the course of the next 6 days     ***R1***

hence if *X* is the number on the power line on Monday and *Y*, the number on the power line Tuesday – Sunday then the numerator is     ***M1***







hence solution is      ***AG***

***[5 marks]***

**22.** *[7 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

(a)     (i)          ***(M1)***

**Note:**     Award ***(M1)*** for use of the product of probabilities.

     ***A1***

          (ii)     binomial distribution      ***(M1)***

**Note:**     Award ***(M1)*** for recognizing the binomial distribution.

     ***A1***

**Note:**     Award ***(M1)A1*** for .

***[4 marks]***

(b)     





     ***(M1)***

**Note:**     Award ***(M1)*** for any of the last three lines. Accept equalities.

     ***(M1)***

**Note:**     Award ***(M1)*** for attempting to solve  using any method, *eg*, logs, graphically, use of solver. Accept an equality.



     ***A1***

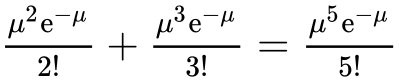
***[3 marks]***

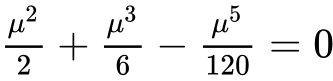
***Total [7 marks]***

**23.** *[4 marks]*

## Markscheme

\* This question is from an exam for a previous syllabus, and may contain minor differences in marking or structure.

(a)          ***(M1)***



     ***A1***

***[2 marks]***

(b)          ***(M1)***





     ***A1***

***[2 marks]***

***Total [4 marks]***

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