Question 1

(a) $\dfrac{6}{15}\left(0.4, \dfrac{2}{5}\right)$ *A1*

[1 mark]

(b) $P(X = 8)$ *(M1)*

> **Note:** Award *(M1)* for evidence of recognizing binomial probability.
>
> *eg,* $P(X = 8)$, $X \sim B\left(20, \dfrac{6}{15}\right)$.

   $0.180\ (0.179705\ldots)$ *A1*

[2 marks]

(c) $P(\text{male}) = \dfrac{9}{15}\ (0.6)$ *A1*

   $P(X \le 9) = 0.128\ (0.127521\ldots)$ *(M1)A1*

> **Note:** Award *(M1)* for evidence of correct approach *eg,* $P(X \le 9)$.

[3 marks]

Total [6 marks]

Question 2

(a) $\dfrac{4}{18}\left(\dfrac{2}{9}\right)$ **A1**

                                                                                              [1 mark]

(b) $-3 \times \dfrac{1}{18} + (-1) \times \dfrac{4}{18} + 0 \times \dfrac{3}{18} + \ldots + 5 \times \dfrac{7}{18}$ **(M1)**

Note: Award **(M1)** for their correct substitution into the formula for expected value.

$= 1.83 \left(\dfrac{33}{18}, 1.83333\ldots\right)$ **A1**

                                                                                              [2 marks]

(c) $2 \times \dfrac{1}{18} \times \dfrac{3}{18}$ **(M1)(M1)**

Note: Award **(M1)** for $\dfrac{1}{18} \times \dfrac{3}{18}$, award **(M1)** for multiplying their product by 2.

$= \dfrac{1}{54} \left(\dfrac{6}{324}, 0.0185185\ldots, 1.85\%\right)$ **A1**

                                                                                              [3 marks]

                                                                                       Total [6 marks]

Question 3

(a) (i) $\mu_1 - \mu_2 = 0$ **A1**

     (ii) $\mu_1 - \mu_2 \neq 0$ **A1**

Note: Accept equivalent statements in words.

                                                                                              [2 marks]

(b) $0.296 \ (0.295739\ldots)$ **A2**

                                                                                              [2 marks]

(c) $0.296 > 0.1$ **R1**

        fail to reject the null hypothesis, there is no difference between the mean
        height of male and female students   **A1**

Note: Award **(R1)** for a correct comparison of their p-value to the test level,
        award **(A1)** for the correct interpretation from that comparison.
        Do not award **R0A1**.

                                                                                              [2 marks]

                                                                                       Total [6 marks]

Question 4

(a) number of salad meals per week is independent of a person's position
     in the university   **A1**

> **Note:** Accept "not associated" instead of independent.

[1 mark]

(b) 0.0201 (0.0201118…)   **A2**

[2 marks]

(c) $0.0201 < 0.05$ **R1**

the null hypothesis is rejected   **A1**

[2 marks]

Total [5 marks]

Question 5

(a) discrete   **A1**

[1 mark]

(b) $\dfrac{24 + 60 + 3k + 40 + 15 + 6}{88 + k} = 2$ **M1A1**

> **Note:** Award **M1** for substitution into the formula for
> the mean, award **A1** for a correct equation.

attempt to solve their equation   **(M1)**

$k = 31$ **A1**

[4 marks]

(c) systematic   **A1**

[1 mark]

Total [6 marks]

Question 6

(a) $210\,\text{g}$ *A1*

       [1 mark]

(b) $240\,\text{g}$ *A1*

       [1 mark]

(c) $240 - 190$ *(M1)*

   $= 50\,\text{g}$ *A1*

       [2 marks]

(d) $240 + 1.5 \times (50)$ *M1*

   $= 315\,\text{g}$ *A1*

       [2 marks]

       Total [6 marks]

Question 7

(a) $\left(\dfrac{74 + 97 + 91 + 86 + 112}{5}\right) = 92$ *A1*

       [1 mark]

(b)   (i) 4 *A1*

   (ii) $\chi^2_{\text{calc}} = 8.54 \ (8.54347...)$ **OR** p-value $= 0.0736 \ (0.0735802...)$ *A2*

       $8.54 < 9.49$ **OR** $0.0736 > 0.05$ *R1*
       therefore there is insufficient evidence to reject H_0 *A1*
       (i.e. the data satisfies the model)

> **Note:** Do not award **R0A1**. Accept "accept" or "do not reject" in
> place of "insufficient evidence to reject".
> Award the **R1** for comparing their p-value with 0.05 or their
> χ^2 value with 9.49 and then **FT** their final conclusion.

       [5 marks]

       Total [6 marks]

Question 8

(a)   (let μ_c = population mean for chinchilla rabbits, μ_s = population mean for sable rabbits)

      $H_0 : \mu_c = \mu_s$ *A1*

      $H_1 : \mu_c > \mu_s$ *A1*

[2 marks]

(b) p-value $= 0.0408$ $(0.0408065...)$ *A2*

(c) $0.0408 < 0.05$.   *R1*

      (there is sufficient evidence to) reject (or not accept) H_0 *A1*

      (there is sufficient evidence to suggest that chinchilla rabbits are heavier than sable rabbits)

[2 marks]
Total [6 marks]

Question 9

(a)   (i)   2   *A1*

      (ii)   6   *A1*

      (iii)   8   *A1*

[3 marks]

(b)   **EITHER**

      Each of these percentages represent approximately 25% of the employees.   *R1*

      OR

      The diagram is not explicit enough to show what is happening at the quartiles regarding 6 and 11 / we do not have the data points   *R1*

      OR

      Discrete data not clear how to interpret "fewer".   *R1*

      THEN

      Hence, Paul is not correct (**OR** no such inference can be made).   *A1*

      Note: Do not award *R0A1*.

[2 marks]

Total [5 marks]

Question 10

(a)

t	1	2	3	4	5	6
$P(T=t)$	$\dfrac{1}{36}$ (0.027777…)	$\dfrac{3}{36}$ (0.083333…)	$\dfrac{5}{36}$ (0.138888…)	$\dfrac{7}{36}$ (0.194444…)	$\dfrac{9}{36}$ (0.25)	$\dfrac{11}{36}$ (0.305555…)

A2

> **Note:** Award **A1** if three to five probabilities are correct.

[2 marks]

(b) (i) $\dfrac{32}{36}$ $\left(\dfrac{8}{9},\ 0.888888...,\ 88.9\%\right)$ **(A1)**

(ii) use of conditional probability **(M1)**
e.g. denominator of 32 **OR** denominator of 0.888888…, etc.

$\dfrac{11}{32}$ (0.34375, 34.4%) **A1**

[3 marks]

(c) $\dfrac{1\times1+3\times2+5\times3+...+11\times6}{36}$ **(M1)**

$=\dfrac{161}{36}$ $\left(4\frac{17}{36},\ 4.47,\ 4.47222...\right)$ **A1**

[2 marks]

Total [7 marks]

Question 11

(a) **EITHER**
H_0: The population mean weight of eggs from (her/the) black geese is equal to/the same as the population mean weight of eggs from (her/the) white geese.

OR

H_0: The population mean weight of eggs from (her/the) black geese is not less than the population mean weight of eggs from (her/the) white geese. **A1**

[1 mark]

(b) p-value $= 0.177$ (0.176953…) **A2**

[2 marks]

(c) $0.177 > 0.1$ **R1**
(insufficient evidence to reject H_0)
Arriane's claim is not supported by the evidence **A1**

[2 marks]

Total [5 marks]

Question 12

(a)   14   A1

[1 mark]

(b) $\dfrac{14+15+\ldots}{10}$ (M1)

$=13.1$ A1

[2 marks]

(c)   2.21 (2.21133...)   A1

[1 mark]

Total [4 marks]

Question 13

(a) $a=0.42$ A1

[1 mark]

(b) $(\mathrm{P}(B'\cap F)=)\ b\times0.68$ A1

[1 mark]

(c)   (i) $0.32\times0.58+0.68b=0.41$ (M1)

> **Note:** Award **(M1)** for setting up equation for fair-haired or equivalent.

$b=0.33$ A1

(ii) $c=0.67$ A1

[3 marks]
Total: [5 marks]

Question 14

(a)   75   *A1*

[1 mark]

(b)   recognition that all entries add up to 120   *(M1)*
$a = 120 - 6 - 13 - 26 - b$ **OR** $a = 75 - b$ *A1*

[2 marks]

(c)   (i) $\dfrac{6 \times 1 + 13 \times 2 + 26 \times 3 + (75 - b) \times 4 + b \times 5}{120} = 3.65$ *(M1)(A1)*

Note: Award *(M1)* for attempt to substitute into mean formula, LHS expression is sufficient for the **M** mark. Award *(A1)* for correct substitutions in one variable **OR** in two variables, followed by evidence of solving simultaneously with $a + b = 75$.

$(b =)\ 28$ *A1*

(ii) $120 -$ their part (c)(i) seen (e.g. 92 indicated on graph)   *(M1)*
84   *A1*

[5 marks]
Total: [8 marks]

Question 15

(a) $r = 0.933\ (0.933419...)$ *A2*

[2 marks]

(b)   strong   *A1*

Note: Answer may include "positive", however this is not necessary for the mark.

[1 mark]

(c) $t = 0.228x + 24.3\ (t = 0.227703...x + 24.3153...)$ *A1*

Note: Condone y in place of t. Answer must be an equation.

[1 mark]

(d) $(t =)\ 0.227703... \times 57 + 24.3153...$ *(M1)*

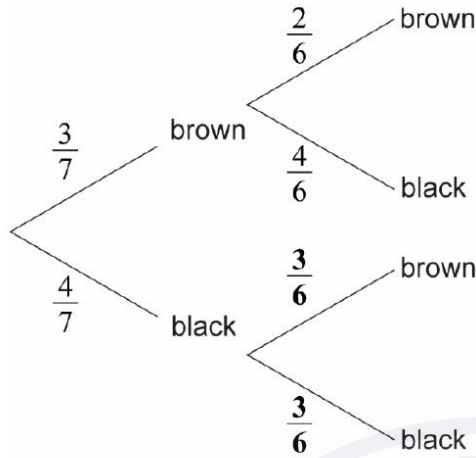**Note:** Award *(M1)* for correct substitution into their regression line.

$(t =)\ 37.3$ minutes (37.2944)   *A1*

Note: Accept 37.1 and 37.4 from use of 2sf and/or 3sf values.

[2 marks]
Total: [6 marks]

Question 16

(a)

A1

[1 mark]

(b)   multiplying along branches and then adding outcomes   *(M1)*

$$\frac{3}{7} \times \frac{2}{6} + \frac{4}{7} \times \frac{3}{6}$$

$$= \frac{18}{42} \left(= \frac{3}{7} \approx 0.429 \ (42.9\%) \right)$$ *A1*

[2 marks]

(c)   use of conditional probability formula   *M1*

$$\frac{\left(\frac{3}{7} \times \frac{2}{6} \right)}{\left(\frac{3}{7} \right)}$$ *A1*

$$= \frac{6}{18} \left(= \frac{1}{3} \right) \ \left(\frac{252}{756}, \ 0.333, \ 33.3\% \right)$$ *A1*

[3 marks]
[Total 6 marks]

Question 17

(a)   50%   *A1*

[1 mark]

(b)   0.0478 (0.0477903…, 4.78%)   *A2*

[2 marks]

(c) $P(X < k) = 0.98$ **OR** $P(X > k) = 0.02$ *(M1)*

506 g (506.161…)   *A2*

[3 marks]
[Total 6 marks]

Question 18

(a) H_0 : The die is fair **OR** $P(\text{any number}) = \frac{1}{6}$ **OR** probabilities are equal

H_1 : The die is not fair **OR** $P(\text{any number}) \neq \frac{1}{6}$ **OR** probabilities are not equal   *A1*

[1 mark]

(b)   5   *A1*

[1 mark]

(c)   10   *A1*

[1 mark]

(d)   (p-value =) 0.287 (0.28724163….)   *A2*

[2 marks]

(e) $0.287 > 0.05$ *R1*

EITHER
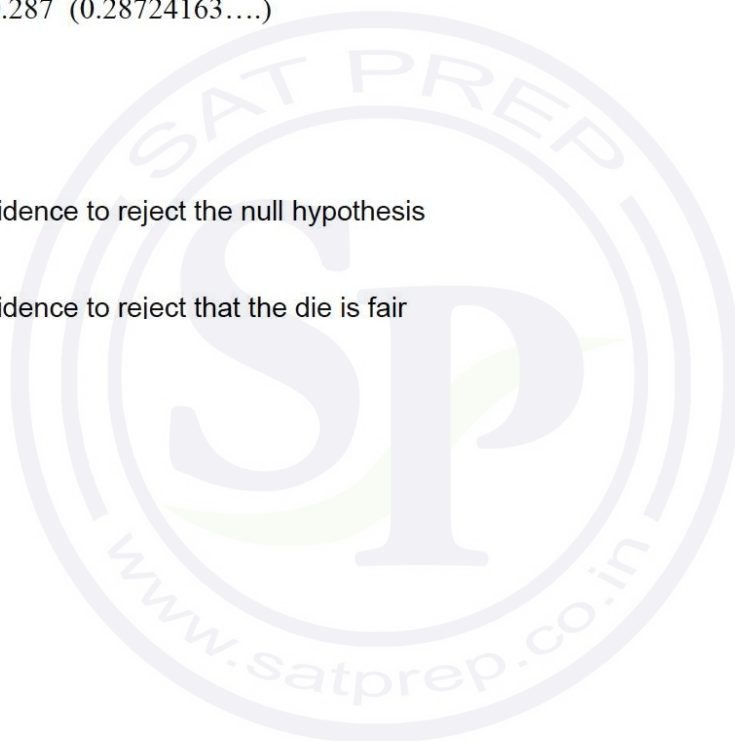Insufficient evidence to reject the null hypothesis   *A1*

OR
Insufficient evidence to reject that the die is fair   *A1*

[2 marks]
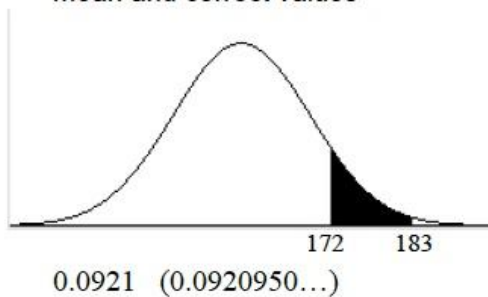*[Total 7 marks]*

Question 19

(a) sketch of normal curve with shaded region to the right of the
     mean and correct values   *(M1)*

     0.0921   (0.0920950…)   **A1**

[2 marks]

(b) **EITHER**
     $\left(\text{P}(x<172)\right)$

     0.906200…   *(A1)*

     $(0.906200… - 0.68)$
     0.226200…   *(A1)*

     OR
     $\left(\text{P}(163<x<172)\right)$

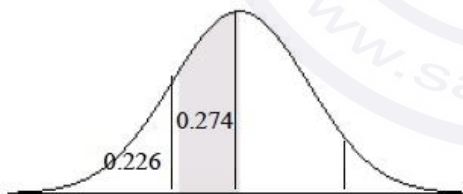   0.406200…   *(A1)*

     $0.5 - (0.68 - 0.406200…)$ **OR** $0.5 + (0.68 - 0.406200…)$
     0.226200… **OR** 0.773799…   *(A1)*

     OR

                                                                                (A1)(A1)

     THEN
     $(k =) 158$ g $(157.867…$g$)$ **A1**

[3 marks]
Total [5 marks]

Question 20

(a)   *Accept any one of the following (or equivalent):*
       one minimum and one maximum point
       three x-intercepts or three roots (or zeroes)
       one point of inflexion   **R1**

> **Note:** Do not accept "S shape" as a justification.

                                                                              [1 mark]

(b)   (i) $(d =) -5$ **A1**

       (ii) $8 = a + b + c$
              $4 = 8a + 4b + 2c$
              $0 = 27a + 9b + 3c$ **A2**

> **Note:** Award **A2** if all three equations are correct.
>   Award **A1** if at least one is correct. Award **A1** for three correct equations
>   that include the letter "d".

       (iii) $a = 2, \ b = -12, \ c = 18$ **A1**

                                                                              [4 marks]

(c)   equating found expression to zero   **(M1)**
       $0 = 2t^3 - 12t^2 + 18t - 5$
       $t = 0.358216\ldots, 1.83174\ldots, 3.81003\ldots$ **(A1)**

       (so total time in debt is $3.81003\ldots - 1.83174\ldots + 0.358216 \approx$)
       $2.34 \ (2.33650\ldots)$ years   **A1**

                                                                              [3 marks]
                                                                       Total [8 marks]

Question 21

(a)   (H_1:) $\mu_1 - \mu_2 \neq 0$ ($\mu_1 \neq \mu_2$)   **A1**

> **Note:** Accept an equivalent statement in words, however reference to "**population** mean" must be explicit for **A1** to be awarded.

[1 mark]

(b)   0.0778   (0.0778465…)   **A2**

> **Note:** Award **A1** for an answer of 0.0815486… from not using a pooled estimate of the variance.

[2 marks]

(c)   (i) $0.0778 < 0.1$ **R1**
         reject the null hypothesis   **A1**

> **Note:** Do not award **R0A1**.

   (ii)   there is (significant evidence of) a difference between the (population) **mean** reaction times   **A1**

> **Note:** Their conclusion in (c)(ii) must match their conclusion in (c)(i) to earn **A1**. Award **A0** if their conclusion refers to mean reaction times in the sample.

[3 marks]
Total [6 marks]

Question 22

(a) $(88 - 62) \times 1.5$ **OR** 26×1.5 seen anywhere   **OR**   39 seen anywhere   **(M1)**

   $62 - 39$
   23   **A1**

   $25 > 23$ **R1**
   so is not an outlier   **AG**

[3 marks]

(b)   The median score for the evening class is higher than the median score for the morning class.   **A1**

   THEN
   but the scores are more spread out in the evening class than in the morning class   **A1**
   OR
   the scores are more inconsistent in the evening class   **A1**
   OR
   the lowest scores are in the evening class   **A1**
   OR
   the interquartile range is lower in the morning class   **A1**

[2 marks]
Total [5 marks]

Question 23

(a) $\left(\mathrm{E}(X)=\right)\,10\times0.8$ (M1)

   8 (people) A1

   [2 marks]

(b) recognition of binomial probability (M1)
   0.0881   (0.0880803…) A1

   [2 marks]

(c) 0.8 and 6 seen   **OR** 0.2 and 3 seen (A1)
   attempt to use binomial probability (M1)
   0.121   (0.120873…) A1

   [3 marks]
   Total *[7 marks]*

Question 24

(a) $\left(\dfrac{17+25}{130}=\right)\dfrac{42}{130}\quad\left(\dfrac{21}{65},\,0.323076…\right)$ A1

   [1 mark]

(b) $\left(\dfrac{17}{17+25}=\right)\dfrac{17}{42}\quad(0.404761…)$ A1A1

Note: Award *A1* for correct numerator and *A1* for correct denominator.
Award *A1A0* for working of $\dfrac{17/130}{\text{their answer to (a)}}$ if followed by an incorrect answer.

   [2 marks]

(c) $\dfrac{41}{130}\times\dfrac{40}{129}$ A1M1

Note: Award *A1* for two correct fractions seen, *M1* for multiplying their fractions.

   $=\dfrac{1640}{16770}\approx0.0978\left(0.0977936…,\,\dfrac{164}{1677}\right)$ A1

   [3 marks]
   Total *[6 marks]*

Question 25

(a) $0.5 \times 0.1 + 0.4 \times 0.4 + 0.1 \times 0.5$ *(M1)(M1)(M1)*

     0.26 *A1*

                                                [4 marks]

(b) $0 = -8 \times 0.5 + 4 \times 0.4 + 0.1k$ *(M1)(M1)*

     $(k =)$ 24 (points)   *A1*

                                                [3 marks]
                                         Total *[7 marks]*

Question 26

(a) $\mathrm{P}(T < 55)$ *(M1)*

     $0.0912 \; (0.0912112...)$ *A1*

> **Note:** Award *M1* for a correct calculator notation such as normal cdf$(0, 55, 59, 3)$ or
> normal cdf$(-1^{99}, 55, 59, 3)$.

                                                       [2 marks]

(b)   correct use of expected value
     $8.6 = 20 \times p$ **OR** $(p =)$ 0.43 seen   *(M1)*
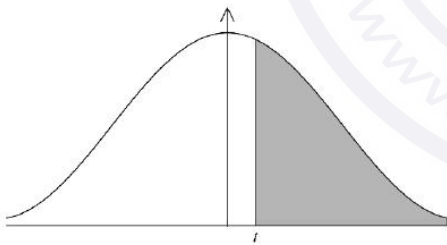
     EITHER
     correct probability statement   *(M1)*
     $\mathrm{P}(T > t) = 0.43$ **OR** $\mathrm{P}(T < t) = 0.57$

     OR
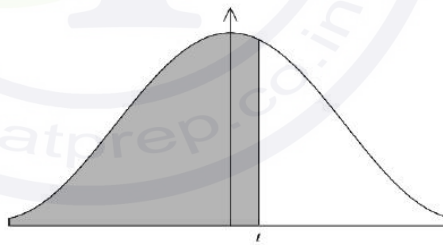 t indicated on sketch to communicate correct area   *(M1)*

     THEN
     $(t =)$ 59.5 (seconds) $(59.5291...)$ *A1*

                                                          [3 marks]
                                                     Total *[5 marks]*

Question 27

(a) $(H_1:)\ \mu_1 \neq \mu_2$ **A1**

> **Note:** Accept an equivalent statement in words referring to μ_1 and μ_2 as defined in the question.

[1 mark]

(b) $0.97652\ (0.976516...)$ **A2**

[2 marks]

(c) $0.97652 > 0.05\ (0.977 > 0.05)$ **R1**
     Annabelle's conclusion is correct.   **A1**

> **Note:** Do not award **R0A1**. Answer must reference Annabelle's conclusion; do not accept an answer, without context, of "fail to reject H_0" for the **A1** mark.

[2 marks]
Total [5 marks]

Question 28

(a)   The favourite breakfast/berry (of adults) is independent of (their) income (level). **A1**

[1 mark]

(b) $\chi^2 = 2.27\ (2.26821...)$ **A2**

[2 marks]

(c)   **EITHER**
     $2.27 < 7.78$ **OR** $2.27 < \text{critical value}$ **R1**
     OR
     $0.687 > 0.1$ (using p-value)

     THEN
     (Do not reject H_0)

     Insufficient evidence (at the 10% significance level) that the favourite berry depends on income level.   **A1**

[2 marks]
Total [5 marks]