Subject – Math AI(Standard Level)
Topic - Statistics and Probability
Year - May 2021 – Nov 2024
Paper -1
Answers

Question 1

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

[1 mark]

(b) $\mathrm{P}(X = 8)$ ***(M1)***

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

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

[2 marks]

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

$\mathrm{P}(X \leq 9) = 0.128\ (0.127521\ldots)$ ***(M1)A1***

Note: Award ***(M1)*** for evidence of correct approach *eg,* $\mathrm{P}(X \leq 9)$.

[3 marks]

Total [6 marks]

Question 2

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

[1 mark]

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

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

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

[2 marks]

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

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

$=\frac{1}{54}\left(\frac{6}{324}, 0.0185185\ldots, 1.85\%\right)$ ***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) $0.0201\ (0.0201118\ldots)$ **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) $\left(\frac{74+97+91+86+112}{5}\right)=92$ **A1**

[1 mark]

(b) (i) 4 **A1**

(ii) $\chi^2_{\text{calc}}=8.54\ (8.54347...)$ **OR** $p\text{-value}=0.0736\ (0.0735802...)$ **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 $\mu_c =$ population mean for chinchilla rabbits, $\mu_s =$ 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
$\mathrm{P}(T=t)$	$\frac{1}{36}$ (0.027777…)	$\frac{3}{36}$ (0.083333…)	$\frac{5}{36}$ (0.138888…)	$\frac{7}{36}$ (0.194444…)	$\frac{9}{36}$ (0.25)	$\frac{11}{36}$ (0.305555…)

A2

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

[2 marks]

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

(ii) use of conditional probability ***(M1)***
e.g. denominator of 32 **OR** denominator of $0.888888…$, etc.
$\frac{11}{32}$ $(0.34375, 34.4\%)$ ***A1***

[3 marks]

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

$=\frac{161}{36}$ $\left(4\frac{17}{36}, 4.47, 4.47222...\right)$ ***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) $\frac{14+15+...}{10}$ **(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) $(\mathrm{P}(B' \cap F)=)\ b \times 0.68$ **A1**

[1 mark]

(c) (i) $0.32 \times 0.58 + 0.68b = 0.41$ **(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) $\dfrac{6\times1+13\times2+26\times3+(75-b)\times4+b\times5}{120}=3.65$ ***(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) $(t=)$ $0.227703...\times57+24.3153...$ ***(M1)***

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

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

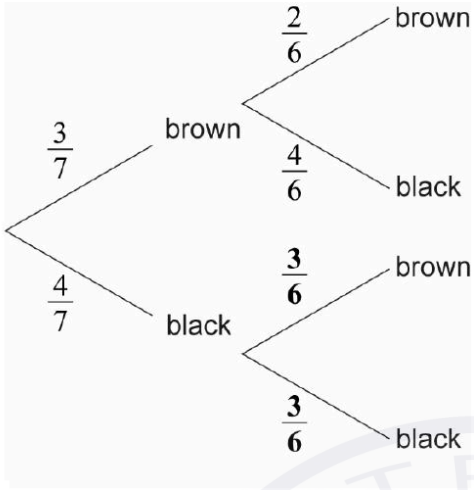
Note: Accept 37.1 and 37.4 from use of 2sf and/or 3sf values.

[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) $\mathrm{P}(X<k)=0.98$ **OR** $\mathrm{P}(X>k)=0.02$ **(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***

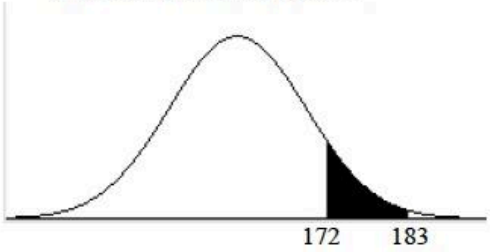
EITHER
Insufficient evidence to reject the null hypothesis ***A1***

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**

$(\mathrm{P}(x < 172))$

0.906200… *(A1)*

(0.906200… – 0.68)

0.226200… *(A1)*

OR

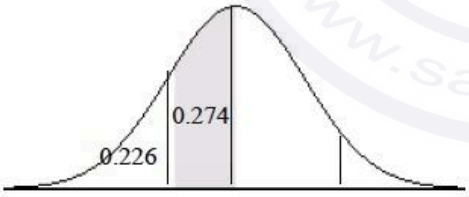
$(\mathrm{P}(163 < x < 172))$

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

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

[1 mark]

(b) $0.0778 \quad (0.0778465\ldots)$ **A2**

Note: Award ***A1*** for an answer of $0.0815486\ldots$ 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) $(E(X) =) 10 \times 0.8$ ***(M1)***

8 (people) ***A1***

[2 marks]

(b) recognition of binomial probability ***(M1)***

$0.0881 \quad (0.0880803\ldots)$ ***A1***

[2 marks]

(c) 0.8 and 6 seen **OR** 0.2 and 3 seen ***(A1)***

attempt to use binomial probability ***(M1)***

$0.121 \quad (0.120873\ldots)$ ***A1***

[3 marks]

Total [7 marks]

Question 24

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

[1 mark]

(b) $\left(\frac{17}{17+25} =\right) \frac{17}{42} \quad (0.404761\ldots)$ ***A1A1***

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

[2 marks]

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

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

$= \frac{1640}{16770} \approx 0.0978 \left(0.0977936\ldots, \frac{164}{1677}\right)$ ***A1***

[3 marks]

Total [6 marks]

Question 25

(a) $0.5\times0.1+0.4\times0.4+0.1\times0.5$ ***(M1)(M1)(M1)***

0.26 ***A1***

[4 marks]

(b) $0=-8\times0.5+4\times0.4+0.1k$ ***(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 $\text{normal cdf}(0, 55, 59, 3)$ or $\text{normal cdf}(-1^{99}, 55, 59, 3)$.

[2 marks]

(b) correct use of expected value

$8.6=20\times p$ **OR** $(p=)$ 0.43 seen ***(M1)***

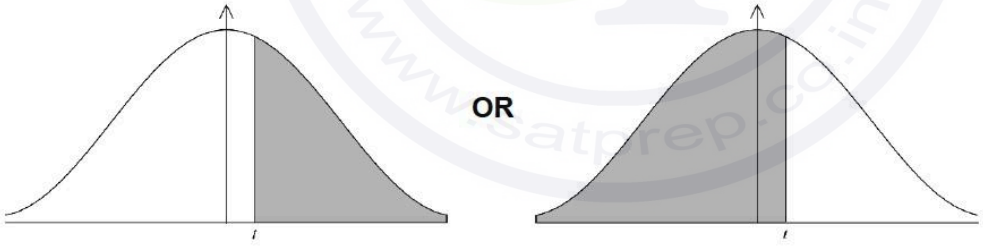
EITHER

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** $2.27 <$ 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]

Question 29

(a) attempt to find the difference between 75.7 and 67.3 ***(M1)***

$\frac{75.7-67.3}{2}$

$4.2\ (\text{km h}^{-1})$ ***A1***

[2 marks]

(b) recognition of normal distribution that includes 72 ***(M1)***

e.g., sketch of normal distribution curve with 72 labelled to the right of the mean **OR**

Normal CDF calculation using 72

0.132 (0.131559…, 13.2%, 13.1559…%) ***A1***

[2 marks]

(c) **METHOD 1 (Comparing areas above and below the mean)**

P(67.3 < speed < 74) **OR** Normal CDF(67.3, 74, 67.3, 4.2) **OR** sketch of normal distributic

with 67.3 and 74 labelled and shaded between ***(M1)***

area of region between mean and q is at least 0.445 (0.444670…) ***A1***

Hence no more than 0.375 (0.375329…) between mean and p ***R1***

The region between p and q is not symmetrical ***AG***

METHOD 2 (Comparing areas in the tails)

attempt to calculate probability that speed $< p$ and speed $> q$ with $q = 74$ ***(M1)***

$\text{P(speed} < 74) = 0.944670\ldots$

$\text{P(speed} < p) = (0.944670\ldots - 0.82 =)\ 0.124670\ldots$

$\text{P(speed} > q) = (1 - 0.944670\ldots =)\ 0.0553295\ldots$ ***A1***

if $q \geq 74$, then $\text{P(speed} > q) \leq 0.0553295$ and $\text{P(speed} < p) \geq 0.124670$ so

$\text{P(speed} > q)$ will never equal $\text{P(speed} < p)$ ***R1***

the region between p and q is not symmetrical ***AG***

METHOD 3 (Assumption of symmetry comparing speeds)

attempt to calculate area below q assuming distribution is symmetrical *(M1)*

e.g. $\mathrm{P}(\text{speed}<q)=0.82+\frac{1}{2}\times 0.18 \quad (0.91)$

EITHER

$(q=)\ 72.9 \quad (72.9311\ldots)$ *A1*

$72.9<74$ so 74 would not be in the region *R1*

the region between p and q is not symmetrical *AG*

OR

$\mathrm{P}(\text{speed}<74)=0.945 \quad (0.944670\ldots)$ *A1*

$0.945>0.91$ so 74 would not be in the region *R1*

the region between p and q is not symmetrical *AG*

METHOD 4 (Assumption of symmetry comparing areas)

attempt to calculate symmetrical area with 74 as a boundary *(M1)*

$\mathrm{P}(60.6<\text{speed}<74)$ **OR** Normal CDF(60.6, 74, 67.3, 4.2) **OR**

$\mathrm{P}(67.3<\text{speed}<74)$ **OR** Normal CDF(67.3, 74, 67.3, 4.2)

EITHER

$0.889 \quad (0.889340\ldots)$ *A1*

$0.889>0.82$ so 74 would not be in the region *R1*

the region between p and q is not symmetrical *AG*

OR

$0.445 \quad (0.444670\ldots)$ *A1*

$0.445>0.82\div 2$ so 74 would not be in the region *R1*

the region between p and q is not symmetrical *AG*

[3 marks]

[Total: 7 marks]

Question 30

(a) $H_0 : \mu_b = \mu_m$ ***A1***

$H_1 : \mu_b > \mu_m$ ***A1***

Note: Accept equivalent statements in words such as "the **mean** score of bilingual people equals the **mean** score of monolingual people".

[2 marks]

(b) 0.119 $(0.119395\ldots)$ ***A2***

[2 marks]

(c) $0.119395\ldots > 0.05$ $(11.9395\ldots\% > 5\%)$ ***R1***

(fail to reject H_0) there is insufficient evidence to suggest that bilingual people have better memory retention than monolingual people ***A1***

Note: Do not award ***R0A1***.
The answer to part (c) MUST be consistent with **their** hypotheses and **their** p-value.

[2 marks]

[Total: 6 marks]

Question 31

(a)

Country	Event		Rank	
	Long Jump (m)	High Jump (m)	Long Jump Rank	High Jump Rank
Germany	7.64	2.11	1	**1**
France	7.52	2.08	2	**2**
Estonia	7.49	1.84	3	**10**
Canada	7.44	2.02	4	**4.5**
Netherlands	7.33	2.05	5	**3**
Ukraine	7.28	2.02	6	**4.5**
Algeria	7.22	1.90	7	**8**
Austria	7.11	1.87	8	**9**
Grenada	6.98	1.99	9	**6**
Japan	6.64	1.96	10	7

A1A1

Note: Award ***A1*** for ranking of tied heights, ***A1*** for correct ranking of non-tied heights.

[2 marks]

(b) $(r_s =)\ 0.541 \quad (0.541035\ldots)$ ***A2***

Note: Award ***A2*** for an answer of $0.539\ (0.539393\ldots)$ from use of the formula for Spearman's rank correlation coefficient when data has tied ranks.

[2 marks]

(c) moderate (correlation) ***A1***

as long jump ranking increases, high jump ranking will (likely) increase ***A1***

[2 marks]

[Total: 6 marks]

Question 31

(a)

Country	Event		Rank	
	Long Jump (m)	High Jump (m)	Long Jump Rank	High Jump Rank
Germany	7.64	2.11	1	**1**
France	7.52	2.08	2	**2**
Estonia	7.49	1.84	3	**10**
Canada	7.44	2.02	4	**4.5**
Netherlands	7.33	2.05	5	**3**
Ukraine	7.28	2.02	6	**4.5**
Algeria	7.22	1.90	7	**8**
Austria	7.11	1.87	8	**9**
Grenada	6.98	1.99	9	**6**
Japan	6.64	1.96	10	7

A1A1

Note: Award ***A1*** for ranking of tied heights, ***A1*** for correct ranking of non-tied heights.

[2 marks]

(b) $(r_s =)\ 0.541 \quad (0.541035\ldots)$ ***A2***

Note: Award ***A2*** for an answer of 0.539 $(0.539393\ldots)$ from use of the formula for Spearman's rank correlation coefficient when data has tied ranks.

[2 marks]

(c) moderate (correlation) ***A1***

as long jump ranking increases, high jump ranking will (likely) increase ***A1***

[2 marks]

[Total: 6 marks]

Question 32

(a) $0.15+0.2+k+0.16+2k+0.25=1$ ***(M1)***

$k=0.08$ ***A1***

[2 marks]

(b) $(-4\times0.15)+(-3\times0.2)+(-1\times0.08)+(0\times0.16)+(1\times0.16)+(4\times0.25)$ ***(M1)***

$=-0.12$ ***A1***

$\mathrm{E}(X)\neq0$ therefore the game is not fair ***R1***

Note: Do not award ***A0R1*** without an explicit value for $\mathrm{E}(X)$ seen. The ***R1*** can be awarded for comparing **their** $\mathrm{E}(X)$ to zero provided working is shown.

[3 marks]

Total [5 marks]

Question 33

(a) $X\sim\mathrm{N}(4,\ 0.25^2)$

EITHER

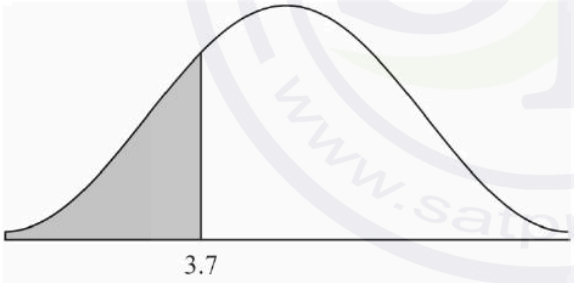
correct probability expression ***(M1)***

$\mathrm{P}(X<3.7)$

Note: Accept a weak or strict inequality, and any label instead of X, e.g. length or L.

OR

normal curve with vertical line, left of mean, labelled 3.7, and shaded region ***(M1)***



THEN

0.115 $(0.115069\ldots,\ 11.5\%)$ ***A1***

Note: Award ***M1A0*** for 0.12 if no previous working.

[2 marks]

(b) **EITHER**

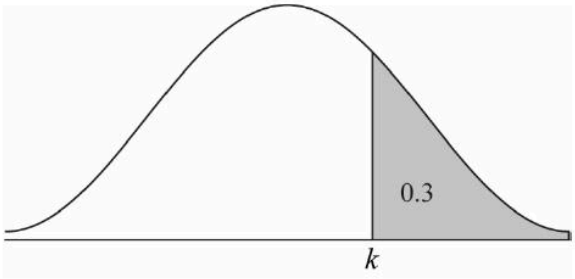
Correct probability expression ***(M1)***

$(\mathrm{P}(X<k)=0.7$ **OR** $\mathrm{P}(X>k)=0.3$

Note: Accept a weak or strict inequality, and any label instead of X *e.g.*, length or L.

OR

normal curve with vertical line to the right of the mean and shaded region, correctly labelled either 0.3 or 0.7 ***(M1)***



THEN

$(k =)\ 4.13\ (4.13110\ldots)$ ***A1***

Note: Award ***M1A0*** for 4.1 if no previous working.

[2 marks]

(c) **EITHER**

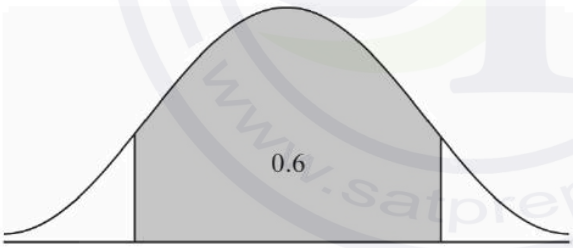
correct probability equation ***(M1)***

$\mathrm{P}(\text{length} < 4 + m) = 0.8$ **OR** $\mathrm{P}(\text{length} < 4 - m) = 0.2$

Note: Accept any letter instead of "length" *e.g.*, X or L.

OR

normal curve with vertical lines symmetrical about the mean line with a correct indication of an area of 0.6 or 0.2 or 0.8 ***(M1)***



THEN

$0.210\ (0.210405\ldots)$ ***A1***

Note: Award ***(M1)A0*** for an answer of 3.7895 or 4.2105 seen without working.

[2 marks]

Total [6 marks]

Question 34

(a) $0.565 \left(0.564655..., \frac{131}{232}, 56.4655...\%\right)$ **A1A1**

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

[2 marks]

(b) $11.0\ (11.0212\ldots)$ **A2**

Note: Award ***A1*** for a final answer of 11 if no unrounded answer is seen.

[2 marks]

(c) **EITHER**
$11.0 > 9.488\ (11.0212\ldots > 9.488\ )$ ***R1***

OR
$0.0263 < 0.05\ (0.0263264\ldots < 0.05\ )$ ***R1***

THEN

EITHER
(there is significant evidence to) reject H_0 ***A1***

OR
(there is significant evidence that) the (food) quality and the type of meal are not independent ***A1***

Note: Do not award ***R0A1.***
Award ***R1*** for $\chi^2_{\text{calc}} > \chi^2_{\text{crit}}$, provided the calculated value is explicitly seen in part (b).

Accept "p-value < significance level" provided their p-value is seen and their p-value is between 0 and 1.

[2 marks]
Total [6 marks]

Question 35

(a) $34 + p$ ***A1***

[1 mark]

(b) attempt to substitute into the mean formula, equating to 4.5 ***(M1)***

$$\frac{1\times1+2\times4...5\times p+6\times9+7\times4}{34+p}=4.5$$ ***A1***

$(p =)\ 10$ ***A1***

Note: Do not award the final ***A1*** if final answer is not an integer.
Award ***(M1)A0A1*** for an unsupported answer of $(p =)\ 10$.

[3 marks]
Total [4 marks]

Question 36

(a)

Athlete	A	B	C	D	E	F	G	H
Age rank	7	6	3	5	4	2	8	1
Time rank	3.5	2	3.5	6	7	8	1	5

A1A1

Note: Award ***A1*** for each correct row.

[2 marks]

(b) $r_s = -0.671\ (-0.670670...)$ ***A2***

Note: Only follow through from an incorrect table provided the ranks are all between 1 and 8.
Award ***A1*** for -0.67 **OR** for the omission of the negative sign, e.g. 0.671 $(0.670670...)$ or 0.67

[2 marks]

(c) (A value of $r_s = -0.671$) indicates a negative correlation between a person's age and the best time they take to run 100m. ***R1***

Note: Condone any comment that includes "weak" or "strong" etc. Accept an interpretation in words, but only if there is a general link described and not a rule: "The older a person gets, the faster they *tend to* run".
Answer must be in context.

[1 mark]

(d) *Award **R1** for any sensible reason:* ***R1***
The correlation, such that it is, is unlikely to be linear for this type of data.
Spearman's CC is less sensitive to outliers
Sung-Jin is not sure the data is drawn from a bivariate normal distribution
There are outliers/extreme data
Same time for two athletes with significantly different ages

[1 mark]
Total [6 marks]

Question 37

(a) (i) 38 (s) **A1**

(ii) 32 (s) **A1**

(iii) 42 (s) **A1**

(iv) 10 (s) **A1**

Note: Accept a tolerance of ± 0.5 for parts (a)(i)-(iii).

[4 marks]

(b) 1.5 x IQR ***(M1)***

$(32 - 1.5 \times 10 =)\ 17\ (s)$ ***A1***

$14 < 17$, therefore it is an outlier ***R1***

Note: Do not award the ***R1*** unless an explicit comparison of 14 and their 17 is seen.
e.g. $14 < 17$
14 is outside the interval $[17, 57]$.

[3 marks]
Total [7 marks]

Question 38

(a) ***A1***

	Artist 1	Artist 2	Artist 3	Artist 4	Artist 5	Artist 6	Artist 7	Artist 8
Rank – social media followers	4	3	6	5	7	2	8	1
Rank – albums sold in first week	**2**	**4**	**8**	**3**	**5**	**6**	**7**	1

[1 mark]

(b) $(r_s =)\ 0.595\ \ (0.595238\ldots)$ ***A2***

[2 marks]

(c) $(H_1 :)$ In the population, there is a **positive** monotonic relationship between the number of social media followers and the number of albums sold in the first week. ***A1***

[1 mark]

(d) $0.595 < 0.643$ ***R1***

there is insufficient evidence to reject H_0 ***A1***

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

[2 marks]
[Total 6 marks]

Question 39

(a) evidence of using binomial distribution **(M1)**

Note: Evidence is $X \sim \mathrm{B}(5,\ 0.72)$ or binomial with $n = 5,\ p = 0.72$.

$0.293 \quad (0.292626\ldots)$ **A1**

[2 marks]

(b) attempt to find the probability of taking a bus, (or *not* taking a bus); **(M1)**
$\mathrm{P(take\ bus)} = 0.28 \times 0.42,\ \mathrm{P(not\ take\ bus)} = 0.72 + 0.28 \times 0.58$

0.1176 or 0.8824 seen **(A1)**

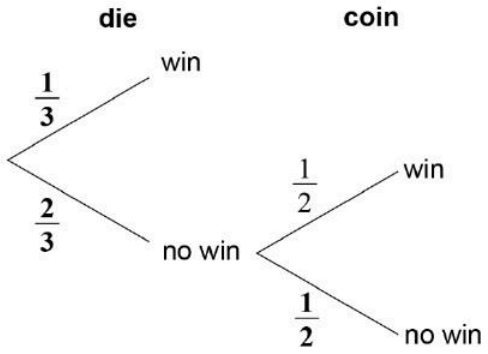
EITHER
correct use of binomial distribution with their probability
$X \sim \mathrm{B}(5,\ 0.1176),\ X = 0$ **OR** $X \sim \mathrm{B}(5,\ 0.8824),\ X = 5$ **(A1)**
OR
$(1 - 0.1176)^5$ **OR** $(0.8824)^5$ seen **(A1)**

THEN
$0.535 \quad (0.534967\ldots)$ **A1**

[4 marks]
[Total 6 marks]

Question 40

(a)



A1A1

Note: Award ***A1*** for completing first set of branches, ***A1*** for completing second set of branches.

[2 marks]

(b) attempt to multiply along the branches ***(M1)***

$\frac{2}{3}\times\frac{1}{2}$

$=\frac{1}{3}\ \ (=0.333...)$ ***A1***

[2 marks]

(c) **EITHER**

$$\frac{\frac{1}{3}}{\frac{1}{3}+\left(\frac{2}{3}\times\frac{1}{2}\right)}$$ ***M1A1***

Note: Award ***M1*** for recognizing conditional probability, ***A1*** for correct substitution.

OR

$$\frac{\frac{1}{3}}{1-\frac{1}{3}}$$ ***M1A1***

Note: Award ***M1*** for recognizing conditional probability, ***A1*** for correct substitution.

THEN

$=\frac{1}{2}$ ***A1***

[3 marks]
[Total 7 marks]

Question 41

(a)

Statement	True (✓)
The data for Class A is normally distributed.	
A higher percentage of students in Class A received a grade less than 70 on the exam, than in Class B.	✓
More students in Class B received a grade greater than 90 on the exam than in Class A.	
The interquartile range for Class B is less than the interquartile range for Class A.	✓

A1A1

Note: Award ***A0A0*** if three or four statements are selected.

[2 marks]

(b) **EITHER**

$H_0 : \mu_1 = \mu_2$ ***A1***

$H_1 : \mu_1 \neq \mu_2$ ***A1***

OR

$H_0 : \mu_A = \mu_B$ ***A1***

$H_1 : \mu_A \neq \mu_B$ ***A1***

Note: Accept an equivalent statement in words, but must include reference to "population mean" / "mean for class A and class B" for the ***A1*** to be awarded.

Do not accept an imprecise "the means are equal".

[2 marks]

(c) p-value $= 0.0952 \ (0.0952085\ldots)$ ***A2***

[2 marks]

(d) $0.0952 > 0.05$ ***R1***

there is insufficient evidence to reject H_0 ***A1***

Note: Do not award ***R0A1***. The answer to part (d) MUST follow through from their hypotheses seen in part (b) and their p-value seen in part (c); if hypotheses are incorrect/reversed, etc., the answer to part (d) must reflect this in order for the ***A1*** to be credited.

[2 marks]

[Total 8 marks]

Question 42

(a) (i) $T = 0.552G + 6.36 \quad (= 0.552139...G + 6.35703...)$ ***A1A1***

Note: Award ***A1*** for **correct** values of a and b, ***A1*** for an equation using these **correct** values.

(ii) $(r =)\ 0.994\ (= 0.993910...)$ ***A1***

there is a (very) strong positive linear correlation ***R1***

Note: If r is missing award ***A0R0***.

[4 marks]

(b) attempt to substitute 13 into their regression equation ***(M1)***

$T = 0.552139...(13) + 6.35703...$

$13.5\ (\text{mins})\ (= 13.5348...)$ ***A1***

[2 marks]

(c) **EITHER**

using the T on G regression line cannot (always) reliably make a prediction for G ***R1***

OR

equation is for Time on Gradient not Gradient on Time. ***R1***

OR

this estimate is an extrapolation ***R1***

OR

there is no reason to assume this new hill has constant gradient ***R1***

[1 mark]

[Total 7 marks]

Question 43

(a) ***A1***

	Artist 1	Artist 2	Artist 3	Artist 4	Artist 5	Artist 6	Artist 7	Artist 8
Rank – social media followers	4	3	6	5	7	2	8	1
Rank – albums sold in first week	**2**	**4**	**8**	**3**	**5**	**6**	7	1

[1 mark]

(b) $(r_s =)\ 0.595\ \ (0.595238\ldots)$ ***A2***

[2 marks]

(c) $(\mathrm{H}_1 :)$ In the population, there is a **positive** monotonic relationship between the number of social media followers and the number of albums sold in the first week. ***A1***

[1 mark]

(d) $0.595 < 0.643$ ***R1***

there is insufficient evidence to reject H_0 ***A1***

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

[2 marks]

[Total 6 marks]

Question 44

(a) evidence of using binomial distribution ***(M1)***

Note: Evidence is $X \sim \mathrm{B}(5,\ 0.65)$ or binomial with $n = 5,\ p = 0.65$.

$0.181\ \ (0.181146\ldots)$ ***A1***

[2 marks]

(b) attempt to find the probability of taking a taxi, (or *not* taking a taxi); ***(M1)***

$\mathrm{P(take\ taxi)} = 0.35 \times 0.45$, $\mathrm{P(not\ take\ taxi)} = 0.65 + 0.35 \times 0.55$

0.1575 or 0.8425 seen ***(A1)***

EITHER

correct use of binomial distribution with their probability

$X \sim \mathrm{B}(5,\ 0.1575)$, $X = 0$ **OR** $X \sim \mathrm{B}(5,\ 0.8425)$, $X = 5$ ***(A1)***

OR

$(1 - 0.1575)^5$ **OR** $(0.8425)^5$ seen ***(A1)***

THEN

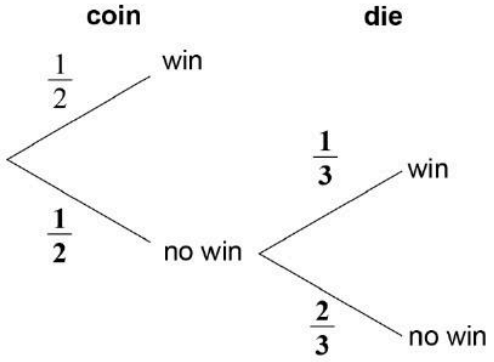
$0.424\ \ (0.424472\ldots)$ ***A1***

[4 marks]

[Total 6 marks]

Question 45

(a)



A1A1

Note: Award ***A1*** for completing first set of branches, ***A1*** for completing second set of branches.

[2 marks]

(b) attempt to multiply along the branches ***(M1)***

$\frac{1}{2}\times\frac{2}{3}$

$=\frac{1}{3}\ \ (=0.333...)$ ***A1***

[2 marks]

(c) **EITHER**

$$\frac{\frac{1}{2}}{\frac{1}{2}+\left(\frac{1}{2}\times\frac{1}{3}\right)}$$ ***M1A1***

Note: Award ***M1*** for recognizing conditional probability, ***A1*** for correct substitution.

OR

$$\frac{\frac{1}{2}}{1-\frac{1}{3}}$$ ***M1A1***

Note: Award ***M1*** for recognizing conditional probability, ***A1*** for correct substitution.

THEN

$=\frac{3}{4}$ ***A1***

[3 marks]
[Total 7 marks]

Question 46

(a)

Statement	True (✓)
A higher percentage of students in Class B received a grade less than 70 on the exam than Class A.	✓
The data for Class B is normally distributed.	
More students in Class A received a grade greater than 90 on the exam than Class B.	
The interquartile range for Class A is less than the interquartile range for Class B.	✓

A1A1

Note: Award ***A0A0*** if three or four statements are selected.

[2 marks]

(b) **EITHER**

$H_0 : \mu_1 = \mu_2$ ***A1***

$H_1 : \mu_1 \neq \mu_2$ ***A1***

OR

$H_0 : \mu_A = \mu_B$ ***A1***

$H_1 : \mu_A \neq \mu_B$ ***A1***

Note: Accept an equivalent statement in words, but must include reference to "population mean" / "mean for class A and class B" for the ***A1*** to be awarded.

Do not accept an imprecise "the means are equal".

[2 marks]

(c) p-value $= 0.111 \ (0.110700\ldots)$ ***A2***

[2 marks]

(d) $0.111 > 0.05$ ***R1***

there is insufficient evidence to reject H_0 ***A1***

Note: Do not award ***R0A1***. The answer to part (d) MUST follow through if hypotheses are incorrect/reversed etc., the answer to part (d) must reflect this in order for the ***A1*** to be credited.

[2 marks]

[Total 8 marks]

Question47

(a) (i) $T = 0.799G + 2.14 \quad (= 0.798803...G + 2.13972...)$ ***A1A1***

Note: Award ***A1*** for **correct** values of a and b, ***A1*** for an equation using these **correct** values.

(ii) $(r =)\ 0.996\ (= 0.996247...)$ ***A1***

(there is a very) strong positive linear correlation ***R1***

Note: If r is missing award ***A0R0***.

[4 marks]

(b) attempt to substitute 17 into their regression equation ***(M1)***

$0.798803...(17) + 2.13972...$

$15.7\ (\text{mins})\ (= 15.7193...)$ ***A1***

[2 marks]

(c) **EITHER**

using the T on G regression line cannot (always) reliably make a prediction for G ***R1***

OR

equation is for Time on Gradient, not Gradient on Time ***R1***

OR

this estimate is an extrapolation ***R1***

OR

there is no reason to assume this new hill has constant gradient ***R1***

[1 mark]

[Total 7 marks]

Question 48

(a) recognizing that only way to score 7 is to achieve a head and a 6 on die **(M1)**

e.g. $\frac{1}{6}$ and $\frac{1}{2}$ seen in an attempt to combine probabilities

$\left(\frac{1}{6}\times\frac{1}{2}=\right)\ \frac{1}{12}\ (0.0833333...)$ **A1**

Note: Accept 0.0835 from the use of 0.167.

[2 marks]

(b) there are two ways to score (e.g.) 5

achieve a head and a 4 on die, or a tail and a 5 on die **(M1)**

$\left(2\left(\frac{1}{6}\times\frac{1}{2}\right)=\right)\ \frac{2}{12}\quad\left(\frac{1}{6},\ 0.167,\ 0.16666...\right)$ **A1**

Note: Award these marks for equivalent working for the 2, 3, 4 or 6 point scenarios.

Final Score	1	2	3	4	5	6	7
Probability	$\frac{1}{12}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{12}$

A1

Note: Award ***A1*** for a completely correct table. Award at most ***(M1)A1A0*** if their follow-through answer from part (a) leads to a total probability not equal to 1.

[3 marks]

(c) **EITHER**

multiplying at least two columns from their table **(M1)**

$1\times\frac{1}{12}+2\times\frac{1}{6}+...+6\times\frac{1}{6}+7\times\frac{1}{12}$

OR

recognizing the probabilities in the table are symmetric **(M1)**

OR *(for HL markscheme and/or removed from SL at publication)*

Considering the sum of two random variables **(M1)**

$\mathrm{E}(X+Y)=\mathrm{E}(X)+\mathrm{E}(Y)\ \ (=3.5+0.5)$

THEN

(expected value $=$) 4 **A1**

Note: Accept 4.01 $(4.00640\ldots)$ from use of their 3 sf values from (b).
Award at most ***M1A0*** if their final answer is not in the range 1 – 7

[2 marks]

[Total: 7 marks]

Question 49

(a) (i) recognition of binomial distribution (condone incorrect parameter) ***(M1)***
e.g. $M \sim \mathrm{B}(20, 0.04)$ **OR** $\mathrm{P}(M = 2) = \mathrm{binpdf}(20, 0.04, 2)$
$= 0.146 \ (0.145799...)$ ***A1***

(ii) recognition the cumulative probability required ***(M1)***
e.g. $\mathrm{P}(M \geq 3) = 1 - \mathrm{bincdf}(20, 0.04, 2)$ **OR** $\mathrm{bincdf}(20, 0.04, 3, 20)$
$= 0.0439 \ (0.0438627...)$ ***A1***

[4 marks]

(b) either one of two terms in expected value formula correct ***(M1)***
$50(20(0.96)) + 15(20(0.04))$
= 972 (pesos) ***A1***

[2 marks]
[Total: 6 marks]

Question 50

(a) H_0: the size of peppers is independent of colour
H_1: the size of peppers is not independent of colour ***A1***

Note: Award ***A1*** for both hypotheses correct. Accept "not associated" in place of independent. Do not accept "correlated" or "related" or "affected".

[1 mark]

(b) (i) $\chi^2_{\text{calc}} = 22.5 \ (22.5483...)$ ***A2***

(ii) $22.5483... > 9.49$ **OR** $0.000155837... < 0.05$ ***R1***
(there is sufficient evidence to) reject the null hypothesis ***A1***

Note: Do not award ***R0A1***.
Accept "accept the alternative hypothesis".
Their conclusion must be consistent with their χ^2_{calc} (or p-value) and their hypothesis.
Accept $\chi^2_{\text{calc}} > \chi^2_{\text{crit}}$ or $p <$ sig level provided their χ^2_{calc} value or p-value is seen.

[4 marks]
[Total: 5 marks]

Question 51

(a) identifying the largest and smallest values: ($)255, ($)49 ***(M1)***
($)206 ***A1***

[2 marks]

(b) (i) ($)137 (137.1) ***(M1)A1***

(ii) ($)74.5 (74.4693…) ***A1***

Note: The ***(M1)*** mark is for correct GDC use and hence can be awarded if either of the values is correct. An answer of 78.4976… in (b)(ii) is awarded ***A0*** but is sufficient to credit the ***(M1)***.

[3 marks]

(c) (i) (mean =) ($)117 (117.1) ***A1***

(ii) (standard deviation =) ($)74.5 (74.4693…) ***A1***

Note: If their answer to part (c)(ii) is incorrect, it should match their answer to part (b)(ii) to be awarded ***A1(FT)***.

[2 marks]
[Total: 7 marks]

Question 52

(a) (i) use of expected value formula. ***(M1)***

$\mathrm{E}(X) = 5\times0.40+(-8)\times0.1+(-5)\times0.2+(-10)\times0.3$

($) -2.8 ***A1***

(ii) Any one of the following ***A1***

- on average, players will lose $2.80 (per game)
- players are expected to/are more likely to lose $2.80 (per game)
- this is the long-term expected average when playing the game many times
- the expected value/it does not equal 0, so the game is not fair

Do not accept:

- players will lose $2.80 (per game)
- players will/are expected to win $-$2.80
- on average, players will lose money
- players are expected to lose money (per game)
- there is more chance of losing money than winning
- the game is not fair

[3 marks]

(b) (i) $\mathrm{E}(X) = 0$ **OR** $\frac{2.80}{0.40}$ ***(M1)***

EITHER

evidence of increase in winning prize ***(M1)***

$5+(k-1)\times1$ **OR** (number of price increases =) 7 **OR**

$\mathrm{E}(X)$ for game $1 = -2.80$, $\mathrm{E}(X)$ for game $2 = -2.40$, etc.

$(5+(k-1)1)\times0.40+(-8)\times0.1+(-5)\times0.2+(-10)\times0.3=0$ ***(A1)***

OR $(4+k)\times0.40+(-8)\times0.1+(-5)\times0.2+(-10)\times0.3=0$

OR $(k=)\ \frac{2.80}{0.40}+1$

$k = 8$ (games) ***A1***

OR

(calculation of winnings to make the game fair)

$(w\times0.40+(-8)\times0.1+(-5)\times0.2+(-10)\times0.3=0)$

$(w=)$ ($) 12 ***(A1)***

evidence of increase in winnings per game up to $12 ***(M1)***

$5, $6, $7, ... $12

$k = 8$ (games) ***A1***

(ii) $\mathrm{E}(X) < 0$ for each (any) of the first 7 games (or equivalent) ***R1***

[5 marks]

[Total: 8 marks]

Question 53

(a) 33 ***A1***

[1 mark]

(b) 12 ***A1***

[1 mark]

(c) $\frac{13}{33}$ $(0.394,\ 0.393939\ldots,\ 39.4\%)$ ***A1***

[1 mark]

(d) $\left(\mathrm{P}(T \cup I) =\right)\ \frac{31}{33}$ $(0.939,\ 0.939393\ldots,\ 93.9\%)$ ***A1***

Note: For ***A1*(ft)** to be awarded, the numerator must be 31 and the denominator must be their answer to part (a).

[1 mark]

(e) $\mathrm{P}(T \cap I) \neq 0$ **OR** $n(T \cap I) \neq 0$ ***R1***

Note: Accept $\mathrm{P}(T) + \mathrm{P}(I) \neq \mathrm{P}(T \cup I)$ provided probabilities are shown. Accept an equivalent statement in words such as "some (13) students went to both cafes" or "students could go to both cafes". Condone $\mathrm{P}(T \text{ and } I) \neq 0$ **OR** $n(T \text{ and } I) \neq 0$

no, they are not mutually exclusive ***A1***

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

[2 marks]
[Total: 6 marks]

Question 54

(a) (i) 1.96 (m) ***A2***

Note: Award ***A1*** for substitution into the formula for the mean e.g. $\frac{1.67+1.60+1.68+...}{6}$.

(ii) 1.94 (m) (1.935) ***A1***

(iii) 2.31 (m) ***A1***

(iv) $2.31-1.60$ ***(M1)***

Note: Award ***M1*** for recognizing 2.31 **and** 1.60 as the critical values.

0.71 (m) ***A1***

[6 marks]

(b) 1.975 (m) **OR** 197.5 (cm) ***A1***

[1 mark]

[Total: 7 marks]

Question 55

(a) recognition that the total probability is 1 ***(M1)***

$0.25+0.4+p=1$

$p=0.35$ ***A1***

[2 marks]

(b) (expected losses is) $60\times$ their p from part (a) ***(A1)***

60×0.35

21 ***A1***

[2 marks]

(c) interpreting that fair game means $\mathrm{E}(X)=0$ (seen anywhere) ***(M1)***

correct expression to calculate **their** $\mathrm{E}(X)$ ***(M1)***

$0.25w+0\times 0.4-5\times$ their p

$(w=)\ 7$ ***A1***

[3 marks]

[Total 7 marks]

Question 56

(a) (i) (mean =) 11 **A1**

(ii) (variance =) 4.95 **A1**

[2 marks]

(b) (i) $(P(X = 14) =)$ 0.0746 (0.0745996…) **A2**

Note: Award ***A1A0*** for an answer of 0.0745 or 0.075.

(ii) recognizing cumulative probability with upper bound of 4 ***(M1)***

$P(X \leq 4)$ **OR** $P(X < 5)$

$= 0.00153$ $(0.0015307442\ldots, 1.53 \times 10^{-3}, 0.153\%)$ **A1**

[4 marks]

(c) **EITHER**

the outcomes of the test are independent of each other **A1**

OR

the probability is constant **A1**

Note: Do not accept "55% will pass". Accept "all students have the same probability of passing the test".

OR

there are only two possible outcomes **A1**

Note: The number of trials is given in the question, and is NOT an assumption.

Do not accept:

"All students have the same driving ability"
"The driving conditions are the same"
"All test are done on sunny days and there is no rain"
"The instructors are fair" etc.

[1 mark]

[Total 7 marks]

Question 57

(a) (i) (mean =) 11 ***A1***

(ii) (variance =) 4.95 ***A1***

[2 marks]

(b) (i) $(P(X = 14) =)$ 0.0746 (0.0745996…) ***A2***

Note: Award ***A1A0*** for an answer of 0.0745 or 0.075.

(ii) recognizing cumulative probability with upper bound of 4 ***(M1)***

$P(X \leq 4)$ **OR** $P(X < 5)$

$= 0.00153$ $(0.0015307442\ldots, 1.53\times10^{-3}, 0.153\%)$ ***A1***

[4 marks]

(c) **EITHER**

the outcomes of the test are independent of each other ***A1***

OR

the probability is constant ***A1***

Note: Do not accept "55% will pass". Accept "all students have the same probability of passing the test".

OR

there are only two possible outcomes ***A1***

Note: The number of trials is given in the question, and is NOT an assumption.

Do not accept:

"All students have the same driving ability"
"The driving conditions are the same"
"All test are done on sunny days and there is no rain"
"The instructors are fair" etc.

[1 mark]

[Total 7 marks]

Question 58

(a) recognizing need to find $P(W > 3.5)$ **OR** $1 - P(W < 3.5)$ ***(M1)***

$(P(W > 3.5) =)$ 0.994 $(0.993790\ldots)$ ***A1***

Note: Award ***M1A0*** for an answer of 0.99 with no working.

[2 marks]

(b) (i) appropriate use of the GDC to find either a or b seen in either (b)(i) or (b)(ii) ***(M1)***

$(a =)$ 3.99 $(3.98737\ldots)$ ***A1***

(ii) $(b =)$ 5.01 $(5.01262\ldots)$ ***A1***

Note: The working for ***(M1)*** may be seen and awarded in part (b)(ii) if part (b)(i) has not been answered.

[3 marks]

(c) multiplying two identical probabilities ***(M1)***

$P(W < 3.5) \times P(W < 3.5)$ **OR** $(1 - \text{their (a)}) \times (1 - \text{their (a)})$

Note: Accept a lower bound of zero for W, given the context.

$(0.00620967)^2$

0.0000386 $(0.0000385601\ldots$ **OR** $3.86 \times 10^{-5})$ ***A1***

Note: Award ***M0A0*** for an answer greater than 1 such as 3.86.
Award ***M1A0*** for 3.86E-5.

[2 marks]
[Total: 7 marks]

Question 59

(a) $\bar{x} = 4.454545\ldots$ $\sigma_x = 1.63560\ldots$ ***(A1)(A1)***

$\bar{x} = 4.455$ $\sigma_x = 1.636$ (both correct to 4 sf) ***A1***

[3 marks]

(b) $\bar{x} = 44.5$ $(44.5454\ldots)$ $\sigma_x = 16.4$ $(16.3560\ldots)$ ***A1A1***

[2 marks]

(c) $\bar{x} = 74.5$ $(74.5454\ldots)$ $\sigma_x = 16.4$ $(16.3560\ldots)$ ***A1A1***

[2 marks]
[Total 7 marks]

Question 60

(a) recognition that the total probability is 1 ***(M1)***

$0.35+0.4+p=1$

$p=0.25$ ***A1***

[2 marks]

(b) (expected losses is) $60\times$ their p from part (a) ***(A1)***

60×0.25

15 ***A1***

[2 marks]

(c) interpreting that fair game means $\mathrm{E}(X)=0$ (seen anywhere) ***(M1)***

correct expression to calculate **their** $\mathrm{E}(X)$ ***(M1)***

$0.35w+0\times 0.4-7\times$ their p

$(w=)\ 5$ ***A1***

[3 marks]

[Total 7 marks]

Question 61

(a) (i) (mean =) 18 **A1**

(ii) (variance =) 7.2 **A1**

[2 marks]

(b) (i) $(P(X = 21) =)$ 0.0823 (0.0822752…) **A2**

Note: Award ***A1A0*** for an answer of 0.0822 or 0.082.

(ii) recognizing cumulative probability with upper bound of 11 ***(M1)***

$P(X \leq 11)$ **OR** $P(X < 12)$

$= 0.00830$ $(0.0083016\ldots, 8.30 \times 10^{-3}, 0.830\%)$ **A1**

[4 marks]

(c) **EITHER**

the outcomes of the test are independent of each other **A1**

OR

the probability is constant **A1**

Note: Do not accept "60% will pass". Accept "all students have the same probability of passing the test".

OR

there are only two possible outcomes **A1**

Note: The number of trials is given in the question, and is NOT an assumption.

Do not accept:

"All students have the same driving ability"
"The driving conditions are the same"
"All test are done on sunny days and there is no rain"
"The instructors are fair" etc.

[1 mark]

[Total 7 marks]

Question 62

(a) recognizing need to find $\mathrm{P}(W > 7.2)$ **OR** $1 - \mathrm{P}(W < 7.2)$ ***(M1)***

$(\mathrm{P}(W > 7.2) =)$ 0.922 $(0.921709\ldots, 92.2\%)$ ***A1***

Note: Award ***M1A0*** for an answer of 0.92 with no working.

[2 marks]

(b) (i) appropriate use of the GDC to find either a or b seen in either (b)(i) or (b)(ii) ***(M1)***

$(a =)$ 7.36 $(7.36213\ldots)$ ***A1***

(ii) $(b =)$ 10.4 $(10.4378\ldots)$ ***A1***

Note: The working for ***(M1)*** may be seen and awarded in part (b)(ii) if part (b)(i) has not been answered.

[3 marks]

(c) multiplying two identical probabilities ***(M1)***

$\mathrm{P}(W < 7.2) \times \mathrm{P}(W < 7.2)$ **OR** $(1 - \text{their (a)}) \times (1 - \text{their (a)})$

Note: Accept a lower bound of zero for W, given the context.

$(0.0782902...)^2$

0.00613 $(0.00612935\ldots$ **OR** $6.13 \times 10^{-3})$ ***A1***

Note: Award ***M0A0*** for an answer greater than 1 such as 6.13.
Award ***M1A0*** for $6.13\text{E-}3$.

[2 marks]
[Total: 7 marks]

Question 63

(a) $\overline{x} = 4.44166...$ $\sigma_x = 1.657286...$ ***(A1)(A1)***

$\overline{x} = 4.442$ $\sigma_x = 1.657$ (both correct to 4 sf) ***A1***

[3 marks]

(b) $\overline{x} = 44.4$ $(44.4166\ldots)$ $\sigma_x = 16.6$ $(16.5728\ldots)$ ***A1A1***

[2 marks]

(c) $\overline{x} = 74.4$ $(74.4166\ldots)$ $\sigma_x = 16.6$ $(16.5728\ldots)$ ***A1A1***

[2 marks]
[Total 7 marks]