Topic 5 Part 3 *[262 marks]*

1a. *[2 marks]*

Markscheme

$\bar{x} = \frac{1\times 0 + 19\times 10}{20} = 9.5$ ***(M1)A1***

[2 marks]

Examiners report

Well done.

1b. *[1 mark]*

Markscheme

median is
10 ***A1***

[1 mark]

Examiners report

Well done.

1c. *[2 marks]*

Markscheme

(i)
19 ***A1***

(ii)
1 ***A1***

[2 marks]

Total [5 marks]

Examiners report

Both parts well done.

2. *[6 marks]*

Markscheme

METHOD 1

to have 3 consecutive losses there must be exactly 5, 4 or 3 losses

the probability of exactly 5 losses (must be 3 consecutive) is $\left(\frac{1}{3}\right)^5$ ***A1***

the probability of exactly 4 losses (with 3 consecutive) is $4\left(\frac{1}{3}\right)^4\left(\frac{2}{3}\right)$ ***A1A1***

Note: First ***A1*** is for the factor 4 and second ***A1*** for the other 2 factors.

the probability of exactly
3 losses (with
3 consecutive) is $3\left(\frac{1}{3}\right)^3\left(\frac{2}{3}\right)^2$ ***A1A1***

Note: First ***A1*** is for the factor 3 and second ***A1*** for the other 2 factors.

(Since the events are mutually exclusive)

the total probability is $\frac{1+8+12}{3^5} = \frac{21}{243}$ $\left(= \frac{7}{81}\right)$ ***A1***

[6 marks]

METHOD 2

Roy loses his job if

A – first 3 games are all lost (so the last 2 games can be any result)

B – first 3 games are not all lost, but middle 3 games are all lost (so the first game is not a loss and the last game can be any result)

or C – first 3 games are not all lost, middle 3 games are not all lost but last 3 games are all lost, (so the first game can be any result but the second game is not a loss)

for A 4^{th} & 5^{th} games can be anything

$\mathrm{P}(A) = \left(\frac{1}{3}\right)^3 = \frac{1}{27}$ ***A1***

for B 1^{st} game not a loss & 5^{th} game can be anything ***(R1)***

$\mathrm{P}(B) = \frac{2}{3} \times \left(\frac{1}{3}\right)^3 = \frac{2}{81}$ ***A1***

for C 1^{st} game anything, 2^{nd} game not a loss ***(R1)***

$\mathrm{P}(C) = 1 \times \frac{2}{3} \times \left(\frac{1}{3}\right)^3 = \frac{2}{81}$ ***A1***

(Since the events are mutually exclusive)

total probability is $\frac{1}{27} + \frac{2}{81} + \frac{2}{81} = \frac{7}{81}$ ***A1***

Note: In both methods all the ***A*** marks are independent.

Note: If the candidate misunderstands the question and thinks that it is asking for exactly 3 losses award ***A1 A1*** and ***A1*** for an answer of $\frac{12}{243}$ as in the last lines of Method 1.

[6 marks]

Total [6 marks]

Examiners report

If a script has lots of numbers with the wrong final answer and no explanation of method it is not going to gain many marks. Working has to be explained. The counting strategy needs to be decided on first. Some candidates misunderstood the context and tried to calculate exactly 3 consecutive losses. Not putting a non-loss as $\frac{2}{3}$ caused unnecessary work.

3a.

[2 marks]

Markscheme

$\mathrm{P}(A \cup B) = \mathrm{P}(A) + \mathrm{P}(B) - \mathrm{P}(A \cap B)$

$\mathrm{P}(A \cap B) = 0.25 + 0.6 = 0.7$ ***M1***

$= 0.15$ ***A1***

[2 marks]

Examiners report

[N/A]

3b.

[2 marks]

Markscheme

EITHER

$\mathrm{P}(A)\mathrm{P}(B)(= 0.25 \times 0.6) = 0.15$ ***A1***

$= \mathrm{P}(A \cap B)$ so independent ***R1***

OR

$\mathrm{P}(A|B) = \frac{\mathrm{P}(A \cap B)}{\mathrm{P}(B)} = \frac{0.15}{0.6} = 0.25$ ***A1***

$= \mathrm{P}(A)$ so independent ***R1***

Note: Allow follow through for incorrect answer to (a) that will result in events being dependent in (b).

[2 marks]

Total [4 marks]

Examiners report

[N/A]

4a.

[2 marks]

Markscheme

$X \sim N(210,\ 22^2)$

$\mathrm{P}(X < 180) = 0.0863$ ***(M1)A1***

[2 marks]

Examiners report

This question was well done with many candidates obtaining full marks. On the whole, but quite a number misunderstood what was required in part (b) and 182 minutes was a repeated incorrect answer. It was disappointing that candidates have not noticed that this answer was clearly too small showing that candidates had not appreciated the context of the question.

4b.

[2 marks]

Markscheme

$\mathrm{P}(X < T) = 0.9 \Rightarrow T = 238 \text{ (mins)}$ ***(M1)A1***

[2 marks]

Total [5 marks]

Examiners report

This question was well done with many candidates obtaining full marks. On the whole, but quite a number misunderstood what was required in part (b) and 182 minutes was a repeated incorrect answer. It was disappointing that candidates have not noticed that this answer was clearly too small showing that candidates had not appreciated the context of the question.

5a.

[2 marks]

Markscheme

$W \sim B(1000,\ 0.1)$ $\left(\text{accept } C_k^{1000}(0.1)^k(0.9)^{1000-k}\right)$ ***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]

Examiners report

Overall this question was well answered. In part (a) a number of candidates did not mention the binomial distribution or failed to state its parameters although they could go on and do the next parts.

5b.

[1 mark]

Markscheme

$\mu (= 1000 \times 0.1) = 100$ ***A1***

[1 mark]

Examiners report

In part (b) most candidates could state the expected value.

5c.

[2 marks]

$\mathrm{P}(W > 89) = \mathrm{P}(W \geq 90) \quad (= 1 - \mathrm{P}(W \leq 89))$

$= 0.867$

0.889

Examiners report

In part (c) many candidates had problems with inequalities due to the discrete nature of the variable. Most candidates that could deal with the inequality were able to use the GDC to obtain the answer.

6a. *[3 marks]*

Markscheme

$2\frac{e^{-m}m^4}{4!} = \frac{e^{-m}m^5}{5!}$ ***M1A1***

$\frac{2}{4!} = \frac{m}{5!}$ or other simplification ***M1***

Note: accept a labelled graph showing clearly the solution to the equation. Do not accept simple verification that $m = 10$ is a solution.

$\Rightarrow m = 10$ ***AG***

[3 marks]

Examiners report

Most candidates successfully finished part (a) with two fundamental errors occurring regularly. Either e was granted powers of 4 and 5 or an attempt to show that the value of m was 10 was made by evaluation.

6b. *[4 marks]*

Markscheme

$P(X = 6|X \le 11) = \frac{P(X=6)}{P(X\le 11)}$ ***(M1) (A1)***

$= \frac{0.063055\ldots}{0.696776\ldots}$ ***(A1)***

$= 0.0905$ ***A1***

[4 marks]

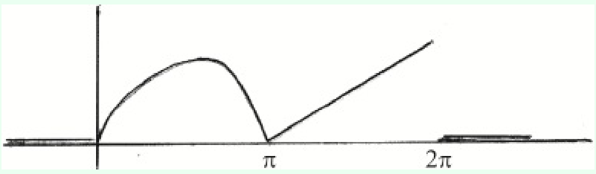
Total [7 marks]

Examiners report

Part (b) was challenging for many candidates that showed that the idea of conditional probability was poorly understood. There were many incorrect solutions where often candidates only found $P(X = 6)$.

7a. *[2 marks]*

Markscheme



Award ***A1*** for sine curve from 0 to π, award ***A1*** for straight line from π to 2π ***A1A1***

[2 marks]

Examiners report

Most candidates sketched the graph correctly. In a few cases candidates did not seem familiar with the shape of the graphs and ignored the fact that the graph represented a pdf. The correct sketch assisted greatly in the rest of the question.

7b. *[2 marks]*

Markscheme

$\int_0^\pi \frac{\sin x}{4}\mathrm{d}x = \frac{1}{2}$ ***(M1)A1***

[2 marks]

Examiners report

Most candidates answered this question correctly.

7c. *[3 marks]*

Markscheme

METHOD 1

require $\frac{1}{2} + \int_\pi^{2\pi} a(x-\pi)\mathrm{d}x = 1$ ***(M1)***

$\Rightarrow \frac{1}{2} + a\left[\frac{(x-\pi)^2}{2}\right]_\pi^{2\pi} = 1 \quad \left(\text{or } \frac{1}{2} + a\left[\frac{x^2}{2} - \pi x\right]_\pi^{2\pi} = 1\right)$ ***A1***

$\Rightarrow a\frac{\pi^2}{2} = \frac{1}{2}$ ***A1***

$\Rightarrow a = \frac{1}{\pi^2}$ ***AG***

Note: Must obtain the exact value. Do not accept answers obtained with calculator.

METHOD 2

$0.5 + \text{ area of triangle } = 1$ ***R1***

area of triangle $= \frac{1}{2}\pi \times a\pi = 0.5$ ***M1A1***

Note: Award ***M1*** for correct use of area formula $= 0.5$, ***A1*** for $a\pi$.

$a = \frac{1}{\pi^2}$ ***AG***

[3 marks]

Examiners report

A few good proofs were seen but also many poor answers where the candidates assumed what you were trying to prove and verified numerically the result.

7d. *[1 mark]*

Markscheme

median is π ***A1***

[1 mark]

Examiners report

Most candidates stated the value correctly but many others showed no understanding of the concept.

7e. *[3 marks]*

Markscheme

$\mu = \int_0^\pi x \cdot \frac{\sin x}{4} \mathrm{d}x + \int_\pi^{2\pi} x \cdot \frac{x-\pi}{\pi^2} \mathrm{d}x$ ***(M1)(A1)***

$= 3.40339\ldots = 3.40 \quad \left(\text{or } \frac{\pi}{4} + \frac{5\pi}{6} = \frac{13}{12}\pi\right)$ ***A1***

[3 marks]

Examiners report

Many candidates scored full marks in this question; many others could not apply the formula due to difficulties in dealing with the piecewise function. For example, a number of candidates divided the final answer by two.

7f. *[3 marks]*

Markscheme

For $\mu = 3.40339\ldots$

EITHER

$\sigma^2 = \int_0^\pi x^2 \cdot \frac{\sin x}{4} \mathrm{d}x + \int_\pi^{2\pi} x^2 \cdot \frac{x-\pi}{\pi^2} \mathrm{d}x - \mu^2$ ***(M1)(A1)***

OR

$\sigma^2 = \int_0^\pi (x-\mu)^2 \cdot \frac{\sin x}{4} \mathrm{d}x + \int_\pi^{2\pi} (x-\mu)^2 \cdot \frac{x-\pi}{\pi^2} \mathrm{d}x$ ***(M1)(A1)***

THEN

$= 3.866277\ldots = 3.87$ ***A1***

[3 marks]

Examiners report

Many misconceptions were identified: use of incorrect formula (e.g. formula for discrete distributions), use of both expressions as integrand and division of the result by 2 at the end.

7g. *[2 marks]*

Markscheme

$\int_{\frac{\pi}{2}}^{\pi} \frac{\sin x}{4} \mathrm{d}x + \int_\pi^{\frac{3\pi}{2}} \frac{x-\pi}{\pi^2} \mathrm{d}x = 0.375 \quad \left(\text{or } \frac{1}{4} + \frac{1}{8} = \frac{3}{8}\right)$ ***(M1)A1***

[2 marks]

Examiners report

This part was fairly well done with many candidates achieving full marks.

7h.

[4 marks]

Markscheme

$\mathrm{P}\left(\pi \le X \le 2\pi \middle| \frac{\pi}{2} \le X \le \frac{3\pi}{2}\right) = \frac{\mathrm{P}\left(\pi \le X \le \frac{3\pi}{2}\right)}{\mathrm{P}\left(\frac{\pi}{2} \le X \le \frac{3\pi}{2}\right)}$ ***(M1)(A1)***

$= \frac{\int_{\pi}^{\frac{3\pi}{2}} \frac{(x-\pi)}{\pi^2} \mathrm{d}x}{0.375} = \frac{0.125}{0.375} \quad \left(\text{or } = \frac{\frac{1}{8}}{\frac{3}{8}} \text{ from diagram areas}\right)$ ***(M1)***

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

[4 marks]

Total [20 marks]

Examiners report

Many candidates had difficulties with this part showing that the concept of conditional probability was poorly understood. The best candidates did it correctly from the sketch.

8a.

[4 marks]

Markscheme

(i) $X \sim Po(5)$

$\mathrm{P}(X \ge 8) = 0.133$ ***(M1)A1***

(ii) $7 \times 0.133\ldots$ ***M1***

$\approx 0.934 \text{ days}$ ***A1***

Note: Accept "
1 day".

[4 marks]

Examiners report

[N/A]

8b.

[3 marks]

Markscheme

$7 \times 5 = 35 \quad (Y \sim Po(35))$ ***(A1)***

$\mathrm{P}(Y \le 29) = 0.177$ ***(M1)A1***

[3 marks]

Total [7 marks]

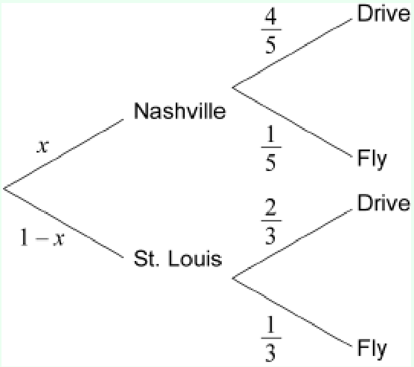
Examiners report

[N/A]

9a.

[3 marks]

Markscheme



attempt to set up the problem using a tree diagram and/or an equation, with the unknown x ***M1***

$\frac{4}{5}x + \frac{2}{3}(1 - x) = \frac{13}{18}$ ***A1***

$\frac{4x}{5} - \frac{2x}{3} = \frac{13}{18} - \frac{2}{3}$

$\frac{2x}{15} = \frac{1}{18}$

$x = \frac{5}{12}$ ***A1***

[3 marks]

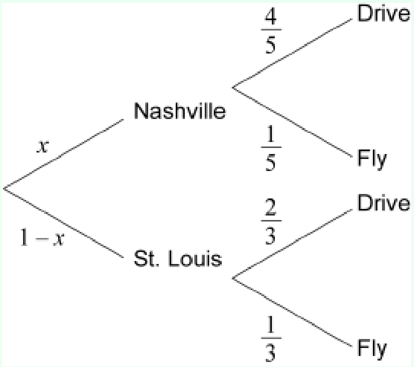
Examiners report

[N/A]

9b.

[3 marks]

Markscheme



attempt to set up the problem using conditional probability ***M1***

EITHER

$\frac{\frac{5}{12} \times \frac{1}{5}}{1 - \frac{13}{18}}$ ***A1***

OR

$\frac{\frac{5}{12} \times \frac{1}{5}}{\frac{1}{12} + \frac{7}{36}}$ ***A1***

THEN

$= \frac{3}{10}$ ***A1***

[3 marks]

Total [6 marks]

Examiners report

[N/A]

10a. *[6 marks]*

Markscheme

(i) $P(110 < X < 130) = 0.49969\ldots = 0.500 = 50.0\%$ ***(M1)A1***

Note: Accept 50

Note: Award ***M1A0*** for 0.50 (0.500)

(ii) $P(X > 130) = (1 - 0.707\ldots) = 0.293\ldots$ ***M1***

expected number of turnips $= 29.3$ ***A1***

Note: Accept 29.

(iii) no of turnips weighing more than 130 is $Y \sim B(100,\ 0.293)$ ***M1***

$P(Y \geq 30) = 0.478$ ***A1***

[6 marks]

Examiners report

[N/A]

10b. *[6 marks]*

Markscheme

(i) $X \sim N(144,\ \sigma^2)$

$P(X \leq 130) = \frac{1}{15} = 0.0667$ ***(M1)***

$P\left(Z \leq \frac{130-144}{\sigma}\right) = 0.0667$

$\frac{14}{\sigma} = 1.501$ ***(A1)***

$\sigma = 9.33\ \text{g}$ ***A1***

(ii) $P(X > 150 | X > 130) = \frac{P(X>150)}{P(X>130)}$ ***M1***

$= \frac{0.26008\ldots}{1-0.06667} = 0.279$ ***A1***

expected number of turnips $= 55.7$ ***A1***

[6 marks]

Total [12 marks]

Examiners report

[N/A]

11a. *[2 marks]*

Markscheme

$\mathrm{P}(L \geq 4995) = 0.785$ ***(M1)A1***

Note: Accept any answer that rounds correctly to 0.79.

Award ***M1A0*** for 0.78.

Note: Award ***M1A0*** for any answer that rounds to 0.55 obtained by taking $\mathrm{SD} = 40$.

[2 marks]

Examiners report

Most candidates solved (a) correctly. In (b) and (c), however, many candidates made the usual error of confusing $\sum_{i=1}^{n} X_i$ and nX. Indeed some candidates even use the second expression to mean the first. This error leads to an incorrect variance and of course an incorrect answer. Some candidates had difficulty in converting the verbal statements into the correct probability statements, particularly in (c).

11b. *[6 marks]*

Markscheme

we are given that $L \sim \mathrm{N}(5000,\ 40)$ and $S \sim \mathrm{N}(1000,\ 25)$

consider $X = L - 5S$ (ignore ± 30) ***(M1)***

$\mathrm{E}(X) = 0$ (± 30 consistent with line above) ***A1***

$\mathrm{Var}(X) = \mathrm{Var}(L) + 25\mathrm{Var}(S) = 40 + 625 = 665$ ***(M1)A1***

require $\mathrm{P}(X \geq 30) \quad (\text{or } \mathrm{P}(X \geq 0) \text{ if } -30 \text{ above})$ ***(M1)***

obtain 0.122 ***A1***

Note: Accept any answer that rounds correctly to 2 significant figures.

[6 marks]

Examiners report

Most candidates solved (a) correctly. In (b) and (c), however, many candidates made the usual error of confusing $\sum_{i=1}^{n} X_i$ and nX. Indeed some candidates even use the second expression to mean the first. This error leads to an incorrect variance and of course an incorrect answer. Some candidates had difficulty in converting the verbal statements into the correct probability statements, particularly in (c).

11c. *[5 marks]*

Markscheme

consider $Y = L - (S_1 + S_2 + S_3 + S_4 + S_5)$ (ignore ± 30) ***(M1)***

$\mathrm{E}(Y) = 0$ (± 30 consistent with line above) ***A1***

$\mathrm{Var}(Y) = 40 + 5 \times 25 = 165$ ***A1***

require $\mathrm{P}(Y \le -30)$ (or $\mathrm{P}(Y \le 0)$ if $+30$ above) ***(M1)***

obtain 0.00976 ***A1***

Note: Accept any answer that rounds correctly to 2 significant figures.

Note: Condone the notation $Y = L - 5S$ if the variance is correct.

[5 marks]

Total [13 marks]

Examiners report

Most candidates solved (a) correctly. In (b) and (c), however, many candidates made the usual error of confusing $\sum_{i=1}^{n} X_i$ and nX. Indeed some candidates even use the second expression to mean the first. This error leads to an incorrect variance and of course an incorrect answer. Some candidates had difficulty in converting the verbal statements into the correct probability statements, particularly in (c).

12a. *[4 marks]*

Markscheme

$\mathrm{P}(X = 0) = 1 - p(= q)$; $\mathrm{P}(X = 1) = p$ ***(M1)(A1)***

$\mathrm{G}_x(t) = \sum_r \mathrm{P}(X = r)t^r$ (or writing out term by term) ***M1***

$= q + pt$ ***A1***

[4 marks]

Examiners report

Solutions to (a) were often disappointing with some candidates simply writing down the answer. A common error was to forget the possibility of X being zero so that $G(t) = pt$ was often seen.

12b. *[2 marks]*

Markscheme

METHOD 1

PGF for $B(n,\ p)$ is $(q + pt)^n$ ***R1***

which is a polynomial of degree n ***R1***

METHOD 2

in n independent trials, it is not possible to obtain more than n successes (or equivalent, *eg*, $\mathrm{P}(X > n) = 0$) ***R1***

so $a_r = 0$ for $r > n$ ***R1***

[2 marks]

Examiners report

Explanations in (b) were often poor, again indicating a lack of ability to give a verbal explanation.

12c. *[5 marks]*

Markscheme

let $Y = X_1 + X_2$

$G_Y(t) = (q_1 + p_1 t)(q_2 + p_2 t)$ ***A1***

$G_Y(t)$ has degree two, so if Y is binomial then

$Y \sim \mathrm{B}(2,\ p)$ for some p ***R1***

$(q + pt)^2 = (q_1 + p_1 t)(q_2 + p_2 t)$ ***A1***

Note: The LHS could be seen as $q^2 + 2pqt + p^2t^2$.

METHOD 1

by considering the roots of both sides, $\frac{q_1}{p_1} = \frac{q_2}{p_2}$ ***M1***

$\frac{1-p_1}{p_1} = \frac{1-p_2}{p_2}$ ***A1***

so $p_1 = p_2$ ***AG***

METHOD 2

equating coefficients,

$p_1 p_2 = p^2,\ q_1 q_2 = q^2 \text{ or } (1 - p_1)(1 - p_2) = (1 - p)^2$ ***M1***

expanding,

$p_1 + p_2 = 2p$ so $p_1,\ p_2$ are the roots of $x^2 - 2px + p^2 = 0$ ***A1***

so $p_1 = p_2$ ***AG***

[5 marks]

Total [11 marks]

Examiners report

Very few complete solutions to (c) were seen with few candidates even reaching the result that $(q_1 + p_1 t)(q_2 + p_2 t)$ must equal $(q + pt)^2$ for some p.

13. *[4 marks]*

Markscheme

using the sum divided by 4 is 13 ***M1***

two of the numbers are 15 ***A1***

(as median is 14) we need a 13 ***A1***

fourth number is 9 ***A1***

numbers are 9, 13, 15, 15 ***N4***

[4 marks]

Examiners report

[N/A]

14. *[5 marks]*

Markscheme

$X : \mathrm{N}(100,\ \sigma^2)$

$\mathrm{P}(X < 124) = 0.68$ ***(M1)(A1)***

$\frac{24}{\sigma} = 0.4676\ldots$ ***(M1)***

$\sigma = 51.315\ldots$ ***(A1)***

variance = 2630 ***A1***

Notes: Accept use of
$\mathrm{P}(X < 124.5) = 0.68$ leading to variance = 2744.

[5 marks]

Examiners report

[N/A]

15a. *[4 marks]*

Markscheme

$\left(A\binom{6}{5}2^5B + 3\binom{6}{4}2^4B^2\right)x^5$ ***M1A1A1***

$= \left(192AB + 720B^2\right)x^5$ ***A1***

[4 marks]

Examiners report

[N/A]

15b. *[4 marks]*

Markscheme

METHOD 1

$x = \frac{1}{6},\ A = \frac{3}{6}\left(= \frac{1}{2}\right),\ B = \frac{4}{6}\left(= \frac{2}{3}\right)$ ***A1A1A1***

probability is

$\frac{4}{81}\ (= 0.0494)$ ***A1***

METHOD 2

P (5 eaten) =P (M eats 1) P (N eats 4) + P (M eats 0) P (N eats 5) ***(M1)***

$= \frac{1}{2}\binom{6}{4}\left(\frac{1}{3}\right)^4\left(\frac{2}{3}\right)^2 + \frac{1}{2}\binom{6}{5}\left(\frac{1}{3}\right)^5\left(\frac{2}{3}\right)$ ***(A1)(A1)***

$= \frac{4}{81}\ (= 0.0494)$ ***A1***

[4 marks]

Examiners report

[N/A]

16a. *[2 marks]*

Markscheme

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

$\mathrm{P}(S > 40) = 1 - \mathrm{P}(S \leqslant 40) = 0.513$ ***A1***

[2 marks]

Examiners report

[N/A]

16b.

[5 marks]

Markscheme

$\frac{\text{probability there were more than 10 on Monday AND more than 40 over the week}}{\text{probability there were more than 10 on Monday}}$ ***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***

$\mathrm{P}(X > 40) + \mathrm{P}(X = 11) \times \mathrm{P}(Y > 29) + \mathrm{P}(X = 12) \times \mathrm{P}(Y > 28) + \ldots$

$+\mathrm{P}(X = 40) \times \mathrm{P}(Y > 0)$

$= \mathrm{P}(X > 40) + \sum\limits_{r=11}^{40} \mathrm{P}(X = r)\mathrm{P}(Y > 40 - r)$

hence solution is

$\frac{\mathrm{P}(X>40)+\sum\limits_{r=11}^{40}\mathrm{P}(X=r)\mathrm{P}(Y>40-r)}{\mathrm{P}(X>10)}$ ***AG***

[5 marks]

Examiners report

[N/A]

17. *[21 marks]*

Markscheme

(a)

$\int_2^3 (ax+b)\mathrm{d}x \ (=1)$ ***M1A1***

$\left[\frac{1}{2}ax^2+bx\right]_2^3 \ (=1)$ ***A1***

$\frac{5}{2}a+b=1$ ***M1***

$5a+2b=2$ ***AG***

[4 marks]

(b) (i)

$\int_2^3 \left(ax^2+bx\right)\mathrm{d}x \ (=\mu)$ ***M1A1***

$\left[\frac{1}{3}ax^3+\frac{1}{2}bx^2\right]_2^3 \ (=\mu)$ ***A1***

$\frac{19}{3}a+\frac{5}{2}b=\mu$ ***A1***

eliminating b ***M1***

eg

$\frac{19}{3}a+\frac{5}{2}\left(1-\frac{5}{2}a\right)=\mu$ ***A1***

$\frac{1}{12}a+\frac{5}{2}=\mu$

$a=12\mu-30$ ***AG***

Note: Elimination of b could be at different stages.

(ii)

$b=1-\frac{5}{2}(12\mu-30)$

$=76-30\mu$ ***A1***

Note: This solution may be seen in part (i).

[7 marks]

(c) (i)

$\int_2^{2.3} (ax+b)\mathrm{d}x \ (=0.5)$ ***(M1)(A1)***

$\left[\frac{1}{2}ax^2+bx\right]_2^{2.3} \ (=0.5)$

$0.645a+0.3b \ (=0.5)$ ***(A1)***

$0.645(12\mu-30)+0.3(76-30\mu)=0.5$ ***M1***

$\mu=2.34 \ \left(=\frac{295}{126}\right)$ ***A1***

(ii)

$\mathrm{E}\left(X^2\right)=\int_2^3 x^2(ax+b)\mathrm{d}x$ ***(M1)***

$a=12\mu-30=-\frac{40}{21},\ b=76-30\mu=\frac{121}{21}$ ***(A1)***

$\mathrm{E}\left(X^2\right)=\int_2^3 x^2\left(-\frac{40}{21}x+\frac{121}{21}\right)\mathrm{d}x=5.539\ldots \ \left(=\frac{349}{63}\right)$ ***(A1)***

$\mathrm{Var}(X) = 5.539\mathrm{K} - (2.341\mathrm{K})^2 = 0.05813\ldots$ ***(M1)***

$\sigma = 0.241$ ***A1***

[10 marks]

Total [21 marks]

Examiners report

[N/A]

18. *[6 marks]*

Markscheme

(a)

$\mathrm{P}(A \cap B) = \mathrm{P}(A|B) \times P(B)$

$\mathrm{P}(A \cap B) = \frac{2}{11} \times \frac{11}{20}$ ***(M1)***

$= \frac{1}{10}$ ***A1***

[2 marks]

(b)

$\mathrm{P}(A \cup B) = \mathrm{P}(A) + \mathrm{P}(B) - \mathrm{P}(A \cap B)$

$\mathrm{P}(A \cup B) = \frac{2}{5} + \frac{11}{20} - \frac{1}{10}$ ***(M1)***

$= \frac{17}{20}$ ***A1***

[2 marks]

(c) No – events A and B are not independent ***A1***

EITHER

$\mathrm{P}(A|B) \neq \mathrm{P}(A)$ ***R1***

$\left(\frac{2}{11} \neq \frac{2}{5}\right)$

OR

$\mathrm{P}(A) \times \mathrm{P}(B) \neq \mathrm{P}(A \cap B)$

$\frac{2}{5} \times \frac{11}{20} = \frac{11}{50} \neq \frac{1}{10}$ ***R1***

Note: The numbers are required to gain ***R1*** in the '**OR**' method only.

Note: Do not award ***A1R0*** in either method.

[2 marks]

Total [6 marks]

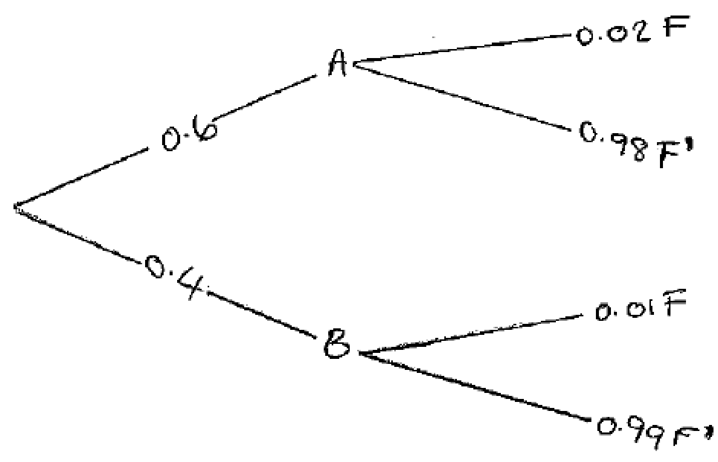
Examiners report

[N/A]

19a. *[6 marks]*

Markscheme

(i)



A1A1

Note: Award ***A1*** for a correctly labelled tree diagram and ***A1*** for correct probabilities.

(ii)

$\mathrm{P}(F) = 0.6 \times 0.02 + 0.4 \times 0.01$ ***(M1)***

$= 0.016$ ***A1***

(iii)

$\mathrm{P}(A|F) = \frac{\mathrm{P}(A \cap F)}{\mathrm{P}(F)}$

$= \frac{0.6 \times 0.02}{0.016} \left(= \frac{0.012}{0.016}\right)$ ***M1***

$= 0.75$ ***A1***

[6 marks]

Examiners report

[N/A]

19b. *[6 marks]*

Markscheme

(i) **METHOD 1**

$\mathrm{P}(X=2)=\frac{{}^3C_2\times{}^4C_1}{{}^7C_3}$ ***(M1)***

$=\frac{12}{35}$ ***A1***

METHOD 2

$\frac{3}{7}\times\frac{2}{6}\times\frac{4}{5}\times 3$ ***(M1)***

$=\frac{12}{35}$ ***A1***

(ii)

x	0	1	2	3
$\mathrm{P}(X=x)$	$\frac{4}{35}$	$\frac{18}{35}$	$\frac{12}{35}$	$\frac{1}{35}$

A2

Note: Award ***A1*** if $\frac{4}{35}$, $\frac{18}{35}$ or $\frac{1}{35}$ is obtained.

(iii)

$\mathrm{E}(X)=\sum x\mathrm{P}(X=x)$

$\mathrm{E}(X)=0\times\frac{4}{35}+1\times\frac{18}{35}+2\times\frac{12}{35}+3\times\frac{1}{35}$ ***M1***

$=\frac{45}{35}=\left(\frac{9}{7}\right)$ ***A1***

[6 marks]

Examiners report

[N/A]

20.

[5 marks]

Markscheme

(a) **METHOD 1**

$\mu = \frac{1}{2} \times (17.1 + 21.3)$ ***(M1)***

$\mu = 19.2$ (kg) ***A1***

finding z value for the upper quartile

$= 0.674489\text{K}$

$0.674489\text{K} = \frac{21.3 - 19.2}{\sigma}$ or

$-0.674489\text{K} = \frac{17.1 - 19.2}{\sigma}$ ***M1***

$\sigma = 3.11$ (kg) ***A1***

METHOD 2

finding z value for the upper quartile

$= 0.674489\text{K}$

from symmetry the z value for a lower quartile is

-0.674489K ***M1***

forming two simultaneous equations:

$-0.674489\text{K} = \frac{17.1 - \mu}{\sigma}$

$0.674489\text{K} = \frac{21.3 - \mu}{\sigma}$ ***M1***

solving gives:

$\mu = 19.2$ (kg) ***A1***

$\sigma = 3.11$ (kg) ***A1***

[4 marks]

(b) using

$100 \times \text{P}(X > 22) = 100 \times 0.184241\text{K}$

$= 18$ ***A1***

Note: Accept 18.4

[1 mark]

Total [5 marks]

Examiners report

[N/A]

21. *[7 marks]*

Markscheme

(a) (i)

$0.6^3 \times 0.4^3$ ***(M1)***

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

$= 0.0138$ ***A1***

(ii) binomial distribution

$X : \mathrm{B}(6,\ 0.6)$ ***(M1)***

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

$\mathrm{P}(X = 3) =$
${}^6C_3(0.6)^3(0.4)^3$

$= 0.276$ ***A1***

Note: Award ***(M1)A1*** for
${}^6C_3 \times 0.0138 = 0.276.$

[4 marks]

(b)

$Y : \mathrm{B}(n,\ 0.4)$

$\mathrm{P}(Y \geqslant 1) > 0.995$

$1 - \mathrm{P}(Y = 0) > 0.995$

$\mathrm{P}(Y = 0) < 0.005$ ***(M1)***

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

$0.6^n < 0.005$ ***(M1)***

Note: Award ***(M1)*** for attempting to solve
$0.6^n < 0.005$ using any method, *eg*, logs, graphically, use of solver. Accept an equality.

$n > 10.4$

$\therefore n = 11$ ***A1***

[3 marks]

Total [7 marks]

Examiners report

[N/A]

22.

[4 marks]

Markscheme

(a)

$\frac{\mu^2 e^{-\mu}}{2!} + \frac{\mu^3 e^{-\mu}}{3!} = \frac{\mu^5 e^{-\mu}}{5!}$ ***(M1)***

$\frac{\mu^2}{2} + \frac{\mu^3}{6} - \frac{\mu^5}{120} = 0$

$\mu = 5.55$ ***A1***

[2 marks]

(b)

$\sigma = \sqrt{5.55\ldots} = 2.35598\ldots$ ***(M1)***

$\mathrm{P}(3.19 \leqslant X \leqslant 7.9)$

$\mathrm{P}(4 \leqslant X \leqslant 7)$

$= 0.607$ ***A1***

[2 marks]

Total [4 marks]

Examiners report

[N/A]

23a.

[4 marks]

Markscheme

(i) use of $\mathrm{P}(A \cup B) = \mathrm{P}(A) + \mathrm{P}(B)$ ***(M1)***

$\mathrm{P}(A \cup B) = 0.2 + 0.5$

$= 0.7$ ***A1***

(ii) use of $\mathrm{P}(A \cup B) = \mathrm{P}(A) + \mathrm{P}(B) - \mathrm{P}(A)\mathrm{P}(B)$ ***(M1)***

$\mathrm{P}(A \cup B) = 0.2 + 0.5 - 0.1$

$= 0.6$ ***A1***

[4 marks]

Examiners report

This part was generally well done.

23b.

[3 marks]

Markscheme

$\mathrm{P}(A|B) = \frac{\mathrm{P}(A \cap B)}{\mathrm{P}(B)}$

$\mathrm{P}(A|B)$ is a maximum when $\mathrm{P}(A \cap B) = \mathrm{P}(A)$

$\mathrm{P}(A|B)$ is a minimum when $\mathrm{P}(A \cap B) = 0$

$0 \le \mathrm{P}(A|B) \le 0.4$ ***A1A1A1***

Note: ***A1*** for each endpoint and ***A1*** for the correct inequalities.

[3 marks]

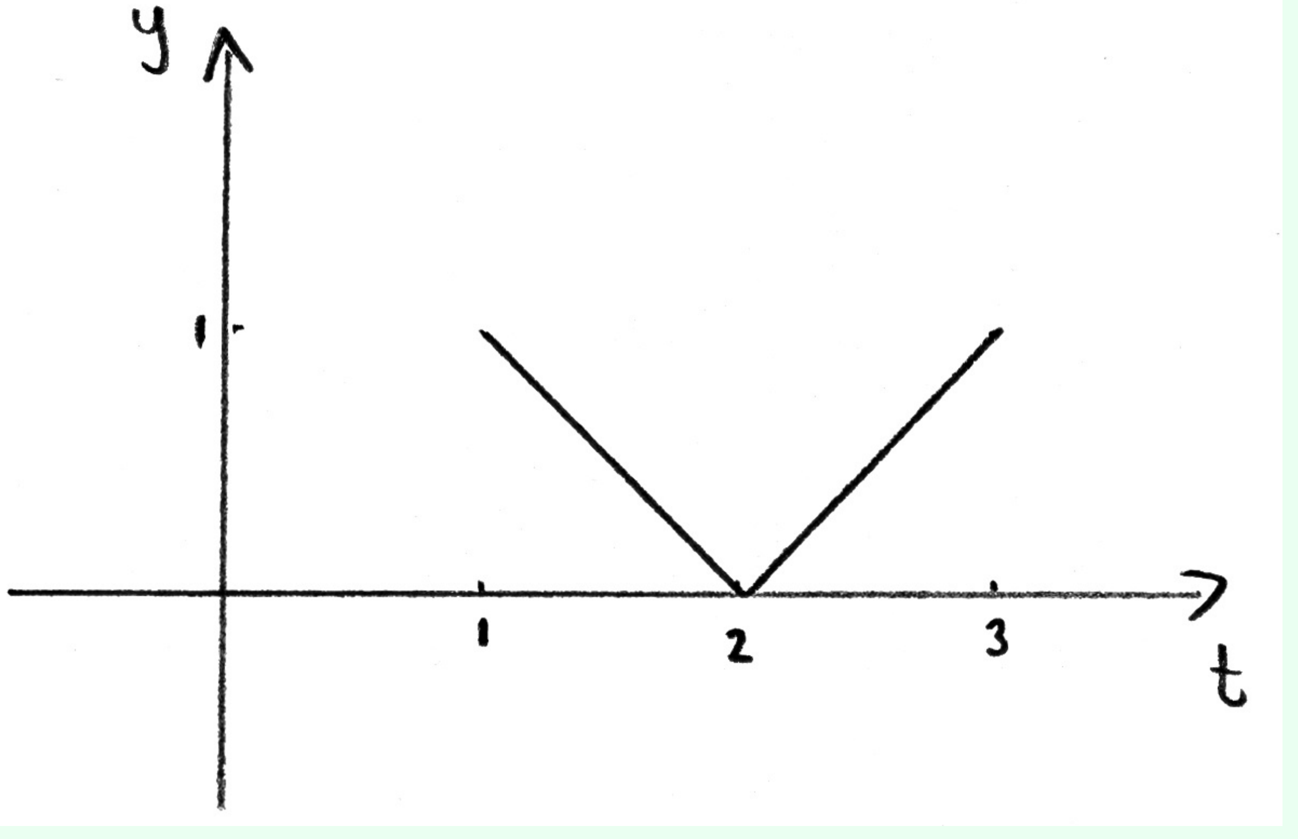
Total [7 marks]

Examiners report

Disappointingly, many candidates did not seem to understand the meaning of the word 'range' in this context.

24a. *[2 marks]*

Markscheme



$|2-t|$ correct for $[1,\ 2]$ ***A1***

$|2-t|$ correct for $[2,\ 3]$ ***A1***

Examiners report

The sketched graphs were mostly acceptable, but sometimes scrappy.

24b. *[4 marks]*

Markscheme

EITHER

let q_1 be the lower quartile and let q_3 be the upper quartile

let $d = 2 - q_1$ $(= q_3 - 2)$ and so $\mathrm{IQR} = 2d$ by symmetry

use of area formulae to obtain $\frac{1}{2}d^2 = \frac{1}{4}$

(or equivalent) ***M1A1***

$d = \frac{1}{\sqrt{2}}$ or the value of at least one q. ***A1***

OR

let q_1 be the lower quartile

consider $\int_1^{q_1} (2 - t)\mathrm{d}t = \frac{1}{4}$ ***M1A1***

obtain $q_1 = 2 - \frac{1}{\sqrt{2}}$ ***A1***

THEN

$\mathrm{IQR} = \sqrt{2}$ ***A1***

Note: Only accept this final answer for the ***A1***.

[4 marks]

Total [6 marks]

Examiners report

Most candidates had some idea about the upper and lower quartiles, but some were rather vague about how to calculate them for this probability density function. Even those who integrated for the lower quartile often made algebraic mistakes in calculating its value.

25a. *[2 marks]*

Markscheme

$\mathrm{P}(X > x) = 0.99 \quad (= \mathrm{P}(X < x) = 0.01)$ ***(M1)***

$\Rightarrow x = 54.6\ (\mathrm{cm})$ ***A1***

[2 marks]

Examiners report

Many candidates did not use the symmetry of the normal curve correctly. Many, for example, calculated the value of x for which $\mathrm{P}(X < x) = 0.99$ rather than $\mathrm{P}(X < x) = 0.01$.

25b. *[3 marks]*

Markscheme

$\mathrm{P}(60.15 \leq X \leq 60.25)$ ***(M1)(A1)***

$= 0.0166$ ***A1***

[3 marks]

Total [5 marks]

Examiners report

Most candidates did not recognize that the required probability interval was $\mathrm{P}(60.15 \leq X \leq 60.25)$. A large number of candidates simply stated that $\mathrm{P}(X = 60.2) = 0.166$. Some candidates used $\mathrm{P}(60.1 \leq X \leq 60.3)$ while a number of candidates bizarrely used probability intervals not centred on 60.2, for example, $\mathrm{P}(60.15 \leq X \leq 60.24)$.

26.

[6 marks]

Markscheme

use of $\mu = \frac{\sum_{i=1}^{k} f_i x_i}{n}$ to obtain $\frac{2+x+y+10+17}{5} = 8$ ***(M1)***

$x + y = 11$ ***A1***

EITHER

use of $\sigma^2 = \frac{\sum_{i=1}^{k} f_i (x_i - \mu)^2}{n}$ to obtain $\frac{(-6)^2+(x-8)^2+(y-8)^2+2^2+9^2}{5} = 27.6$ ***(M1)***

$(x-8)^2 + (y-8)^2 = 17$ ***A1***

OR

use of $\sigma^2 = \frac{\sum_{i=1}^{k} f_i x_i^2}{n} - \mu^2$ to obtain $\frac{2^2+x^2+y^2+10^2+17^2}{5} - 8^2 = 27.6$ ***(M1)***

$x^2 + y^2 = 65$ ***A1***

THEN

attempting to solve the two equations ***(M1)***

$x = 4$ and $y = 7$ $(\text{only as } x < y)$***A1*** ***N4***

Note: Award ***A0*** for $x = 7$ and $y = 4$.

Note: Award ***(M1)A1(M0)A0(M1)A1*** for $x + y = 11 \Rightarrow x = 4$ and $y = 7$.

[6 marks]

Examiners report

Reasonably well done. Most candidates were able to obtain $x + y = 11$. Most manipulation errors occurred when candidates attempted to form the variance equation in terms of x and y. Some candidates did not apply the condition $x < y$ when determining their final answer.

27a.

[3 marks]

Markscheme

(i) $P(X = 0) = 0.549\ (= \mathrm{e}^{-0.6})$ ***A1***

(ii) $P(X \geq 3) = 1 - P(X \leq 2)$ ***(M1)***

$P(X \geq 3) = 0.0231$ ***A1***

[3 marks]

Examiners report

Parts (a), (b) and (d) were generally well done. In (a) (ii), some candidates calculated $1 - \mathrm{P}(X \leq 3)$.

27b.

[2 marks]

Markscheme

EITHER

using $Y \sim \mathrm{Po}(3)$ ***(M1)***

OR

using $(0.549)^5$ ***(M1)***

THEN

$\mathrm{P}(Y=0)=0.0498\ \left(=\mathrm{e}^{-3}\right)$ ***A1***

[2 marks]

Examiners report

Parts (a), (b) and (d) were generally well done.

27c.

[3 marks]

Markscheme

$\mathrm{P}(X=0)$ (most likely number of complaints received is zero) ***A1***

EITHER

calculating $\mathrm{P}(X=0)=0.549$ and $\mathrm{P}(X=1)=0.329$ ***M1A1***

OR

sketching an appropriate (discrete) graph of $\mathrm{P}(X=x)$ against x ***M1A1***

OR

finding $\mathrm{P}(X=0)=e^{-0.6}$ and stating that $\mathrm{P}(X=0)>0.5$ ***M1A1***

OR

using $\mathrm{P}(X=x)=\mathrm{P}(X=x-1)\times\frac{\mu}{x}$ where $\mu<1$ ***M1A1***

[3 marks]

Examiners report

A number of candidates offered clear and well-reasoned solutions to part (c). The two most common successful approaches used to justify that the most likely number of complaints received is zero were either to calculate $\mathrm{P}(X=x)$ for $x=0,\ 1,\ \ldots$ or find that $\mathrm{P}(X=0)=0.549\ (>0.5)$. A number of candidates stated that the most number of complaints received was the mean of the distribution $(\lambda=0.6)$.

27d.

[2 marks]

Markscheme

$\mathrm{P}(X=0)=0.8\ (\Rightarrow e^{-\lambda}=0.8)$ ***(A1)***

$\lambda=0.223\ \left(=\ln\frac{5}{4},=-\ln\frac{4}{5}\right)$ ***A1***

[2 marks]

Total [10 marks]

Examiners report

Parts (a), (b) and (d) were generally well done.

28a. *[1 mark]*

Markscheme

$\mathrm{P}(\text{Ava wins on her first turn}) = \frac{1}{3}$ ***A1***

[1 mark]

Examiners report

Parts (a) and (b) were straightforward and were well done.

28b. *[2 marks]*

Markscheme

$\mathrm{P}(\text{Barry wins on his first turn}) = \left(\frac{2}{3}\right)^2$ ***(M1)***

$= \frac{4}{9} \quad (= 0.444)$ ***A1***

[2 marks]

Examiners report

Parts (a) and (b) were straightforward and were well done.

28c. *[4 marks]*

Markscheme

P(Ava wins in one of her first three turns)

$= \frac{1}{3} + \left(\frac{2}{3}\right)\left(\frac{1}{3}\right)\frac{1}{3} + \left(\frac{2}{3}\right)\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)\left(\frac{1}{3}\right)\frac{1}{3}$ ***M1A1A1***

Note: Award ***M1*** for adding probabilities, award ***A1*** for a correct second term and award ***A1*** for a correct third term.

Accept a correctly labelled tree diagram, awarding marks as above.

$= \frac{103}{243} \quad (= 0.424)$ ***A1***

[4 marks]

Examiners report

Parts (c) and (d) were also reasonably well done.

28d.

[4 marks]

Markscheme

$\mathrm{P(Ava\ eventually\ wins)} = \frac{1}{3} + \left(\frac{2}{3}\right)\left(\frac{1}{3}\right)\frac{1}{3} + \left(\frac{2}{3}\right)\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)\left(\frac{1}{3}\right)\frac{1}{3} + \ldots$ ***(A1)***

using $S_\infty = \frac{a}{1-r}$ with $a = \frac{1}{3}$ and $r = \frac{2}{9}$ ***(M1)(A1)***

Note: Award ***(M1)*** for using $S_\infty = \frac{a}{1-r}$ and award ***(A1)*** for $a = \frac{1}{3}$ and $r = \frac{2}{9}$.

$= \frac{3}{7} \quad (= 0.429)$ ***A1***

[4 marks]

Total [11 marks]

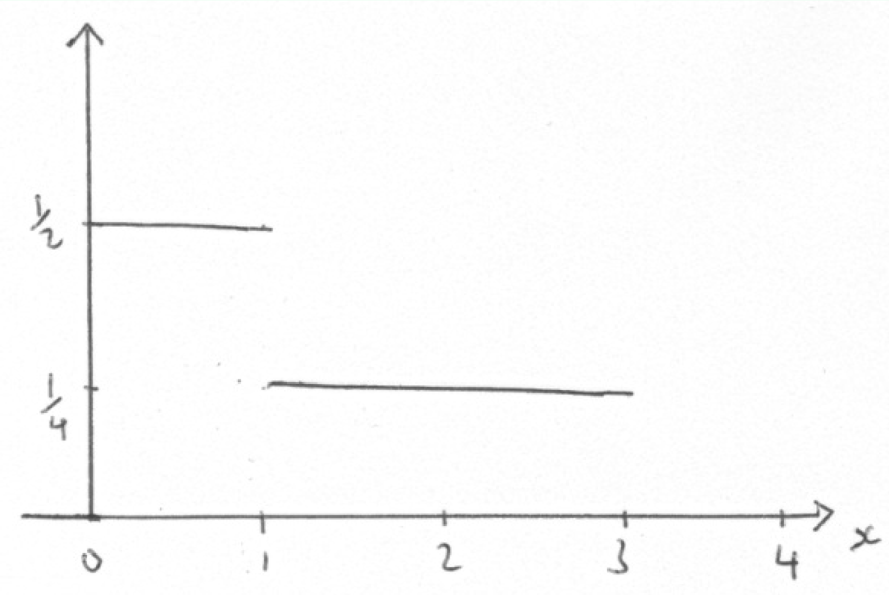
Examiners report

Parts (c) and (d) were also reasonably well done. A pleasingly large number of candidates recognized that an infinite geometric series was required in part (d).

29a.

[1 mark]

Markscheme



A1

Note: Ignore open / closed endpoints and vertical lines.

Note: Award ***A1*** for a correct graph with scales on both axes and a clear indication of the relevant values.

[1 mark]

Examiners report

Part (a) was correctly answered by most candidates. Some graphs were difficult to mark because candidates drew their lines on top of the ruled lines in the answer book. Candidates should be advised not to do this. Candidates should also be aware that the command term ‘sketch’ requires relevant values to be indicated.

29b.

[5 marks]

Markscheme

$$F(x)=\begin{cases}0 & x<0\\ \frac{x}{2} & 0\le x<1\\ \frac{x}{4}+\frac{1}{4} & 1\le x<3\\ 1 & x\ge 3\end{cases}$$

considering the areas in their sketch or using integration ***(M1)***

$F(x)=0,\ x<0,\ F(x)=1,\ x\ge 3$ ***A1***

$F(x)=\frac{x}{2},\ 0\le x<1$ ***A1***

$F(x)=\frac{x}{4}+\frac{1}{4},\ 1\le x<3$ ***A1A1***

Note: Accept $<$ for $\le$ in all places and also $>$ for $\ge$ first ***A1***.

[5 marks]

Examiners report

In (b), most candidates realised that the cumulative distribution function had to be found by integration but the limits were sometimes incorrect.

29c.

[3 marks]

Markscheme

$Q_3=2,\ Q_1=0.5$ ***A1A1***

$\text{IQR is } 2-0.5=1.5$ ***A1***

[3 marks]

Total [9 marks]

Examiners report

In (c), candidates who found the upper and lower quartiles correctly sometimes gave the interquartile range as $[0.5,\ 2]$. It is important for candidates to realise that that the word range has a different meaning in statistics compared with other branches of mathematics.

30a.

[6 marks]

Markscheme

(i) $G'(t)=\lambda e^{\lambda(t-1)}$ ***A1***

$\text{E}(X)=G'(1)$ ***M1***

$=\lambda$ ***AG***

(ii) $G''(t)=\lambda^2e^{\lambda(t-1)}$ ***M1***

$\Rightarrow G''(1)=\lambda^2$ ***(A1)***

$\text{Var}(X)=G''(1)+G'(1)-(G'(1))^2$ ***(M1)***

$=\lambda^2+\lambda-\lambda^2$ ***A1***

$=\lambda$ ***AG***

[6 marks]

Examiners report

Solutions to the different parts of this question proved to be extremely variable in quality with some parts well answered by the majority of the candidates and other parts accessible to only a few candidates. Part (a) was well answered in general although the presentation was sometimes poor with some candidates doing the differentiation of $G(t)$ and the substitution of $t = 1$ simultaneously.

30b. *[3 marks]*

Markscheme

(i) $\mathrm{E}(S) = 2\lambda - \lambda = \lambda$ ***A1***

(ii) $\mathrm{Var}(S) = 4\lambda + \lambda = 5\lambda$ ***(A1)A1***

Note: First ***A1*** can be awarded for either 4λ or λ.

[3 marks]

Examiners report

Part (b) was well answered in general, the most common error being to state that $\mathrm{Var}(2X - Y) = \mathrm{Var}(2X) - \mathrm{Var}(Y)$.

30c. *[3 marks]*

Markscheme

(i) $\mathrm{E}(T) = \frac{\lambda}{2} + \frac{\lambda}{2} = \lambda$ (so T is an unbiased estimator) ***A1***

(ii) $\mathrm{Var}(T) = \frac{1}{4}\lambda + \frac{1}{4}\lambda = \frac{1}{2}\lambda$ ***A1***

this is less than $\mathrm{Var}(S)$, therefore T is the more efficient estimator ***R1AG***

Note: Follow through their variances from (b)(ii) and (c)(ii).

[3 marks]

Examiners report

Parts (c) and (d) were well answered by the majority of candidates.

30d. *[1 mark]*

Markscheme

no, mean does not equal the variance ***R1***

[1 mark]

Examiners report

Parts (c) and (d) were well answered by the majority of candidates.

30e.

[3 marks]

Markscheme

$G_{X+Y}(t) = e^{\lambda(t-1)} \times e^{\lambda(t-1)} = e^{2\lambda(t-1)}$ ***M1A1***

which is the probability generating function for a Poisson with a mean of 2λ ***R1AG***

[3 marks]

Examiners report

Solutions to (e), however, were extremely disappointing with few candidates giving correct solutions. A common incorrect solution was the following:

$G_{X+Y}(t) = G_X(t)G_Y(t)$

Differentiating,

$G'_{X+Y}(t) = G'_X(t)G_Y(t) + G_X(t)G'_Y(t)$

$\mathrm{E}(X+Y) = G'_{X+Y}(1) = \mathrm{E}(X) \times 1 + \mathrm{E}(Y) \times 1 = 2\lambda$

This is correct mathematics but it does not show that $X+Y$ is Poisson and it was given no credit. Even the majority of candidates who showed that $G_{X+Y}(t) = \mathrm{e}^{2\lambda(t-1)}$ failed to state that this result proved that $X+Y$ is Poisson and they usually differentiated this function to show that $\mathrm{E}(X+Y) = 2\lambda$.

30f.

[2 marks]

Markscheme

(i) $G_{X+Y}(1) = 1$ ***A1***

(ii) $G_{X+Y}(-1) = e^{-4\lambda}$ ***A1***

[2 marks]

Examiners report

In (f), most candidates stated that $G_{X+Y}(1) = 1$ even if they were unable to determine $G_{X+Y}(t)$ but many candidates were unable to evaluate $G_{X+Y}(-1)$. Very few correct solutions were seen to (g) even if the candidates correctly evaluated $G_{X+Y}(1)$ and $G_{X+Y}(-1)$.

30g.

[3 marks]

Markscheme

$G_{X+Y}(1) = p(0) + p(1) + p(2) + p(3) \ldots$

$G_{X+Y}(-1) = p(0) - p(1) + p(2) - p(3) \ldots$

so $2\mathrm{P}(\text{even}) = G_{X+Y}(1) + G_{X+Y}(-1)$ ***(M1)(A1)***

$\mathrm{P}(\text{even}) = \frac{1}{2}(1 + e^{-4\lambda})$ ***A1***

[3 marks]

Total [21 marks]

Examiners report

[N/A]

31a.

[3 marks]

Markscheme

$\bar{X} \sim N\left(5.2,\ \frac{1.2^2}{16}\right)$ ***(M1)***

critical value is $5.2 - 1.64485\ldots \times \frac{1.2}{4} = 4.70654\ldots$ ***(A1)***

critical region is $]-\infty,\ 4.71]$ ***A1***

Note: Allow follow through for the final ***A1*** from their critical value.

Note: Follow through previous values in (b), (c) and (d).

[3 marks]

Examiners report

Solutions to this question were generally disappointing.

In (a), the standard error of the mean was often taken to be $\sigma(1.2)$ instead of $\frac{\sigma}{\sqrt{n}}(0.3)$ and the solution sometimes ended with the critical value without the critical region being given.

31b.

[2 marks]

Markscheme

$0.9 \times 0.05 + 0.1 \times (1 - 0.361\ldots) = 0.108875997\ldots = 0.109$ ***M1A1***

Note: Award ***M1*** for a weighted average of probabilities with weights $0.1, 0.9$.

[2 marks]

Examiners report

In (c), the question was often misunderstood with candidates finding the weighted mean of the two means, ie $0.9 \times 5.2 + 0.1 \times 4.6 = 5.14$ instead of the weighted mean of two probabilities.

31c.

[3 marks]

Markscheme

attempt to use conditional probability formula ***M1***

$\frac{0.9 \times 0.05}{0.108875997\ldots}$ ***(A1)***

$= 0.41334\ldots = 0.413$ ***A1***

[3 marks]

Total [10 marks]

Examiners report

Without having the solution to (c), part (d) was inaccessible to most of the candidates so that very few correct solutions were seen.