| Question Number | Scheme | Marks |
|---|---|---|
| 1(a) | **List\database\register (o.e)** of **all** the **students** [in the school] | B1 |
| | | (1) |
| (b) | Individual **student(s)** | B1 |
| | | (1) |
| (c) | Advantage: Less time consuming to obtain/analyse it or less expensive | B1 |
| | Disadvantage: Less precise or may not be representative | B1 |
| | | (2) |
| | **Notes** | **Total 4** |

| | | |
|---|---|---|
| (a) | **B1** | For a suitable sampling frame e.g. a list/database/ register/ spreadsheet of all students and indicating that it contains **all** (can be implied) students in the school. Do not allow what maybe be a partial list (e.g. a list of 50 students, students/number of students who use canteen etc) |
| (b) | **B1** | For a suitable sampling units e.g. student (s) at the school / student (s) who complete the survey (about the canteen). Do not allow student (s) satisfaction / opinion (o.e.) |
| | **Part (c)** | **If there are no label stating advantage / disadvantage, then mark the first as the advantage and the second as disadvantage.** **Allow multiple statements but if they have a contradictory statement – lose B mark** |
| (c) | **B1** | A correct advantage of taking a random sample. e.g. Quicker / cheaper/ less time consuming compared to a census etc B1<br>If not labelled, assume the response refers to the sample |
| | **B1** | A correct disadvantage of taking a random sample. e.g. Not accurate/ information obtained can be inaccurate / It is less accurate compared to a census etc – B1 Any reference to bias - B0<br>If not labelled, assume the response refers to the sample |

| Question Number | Scheme | Marks |
|---|---|---|
| 2(a) | F(5) = 1 so [$k(5+3)=1$] or F(5) – F(-3) = 1 so [$k(5+3) - k(-3+3) = 1$] | M1 |
| | $8k = 1$ so $k = \frac{1}{8}$ * | A1* |
| | | (2) |
| (b)(i) | [ P($X$ > 2) = ]1 – F(2) = $1-\frac{1}{8}(2+3)$ **or** $\int_{[2]}^{[5]}\frac{1}{8}\,dx = \left[\frac{x}{8}\right]_{[2]}^{[5]}$ or 1 – (F(2) – F(-3)) | M1 |
| | $=\frac{3}{8}$ | A1 |
| (ii) | [P($X$ = 5) = ] 0 | B1 |
| | | (3) |
| (c) | $\left[\frac{d}{dx}F(x)\right] = \frac{d}{dx}\left[\frac{1}{8}(x+3)\right] = \frac{1}{8}$ | M1 |
| | $f(x) = \begin{cases} \frac{1}{8} & -3 \leqslant x \leqslant 5 \\ 0 & \text{otherwise} \end{cases}$ | A1 A1 |
| | | (3) |
| (d) | [Continuous] uniform | B1 |
| | | (1) |
| (e)(i) | $E(X) = \frac{-3+5}{2} = 1$ | B1 |
| (ii) | $[\text{Var}(X)] = \frac{(5+3)^2}{12}$ **or** $[\text{Var(X)}] = \left[\frac{x^3}{3}\,\text{"f }(x)\text{"}\right]_{-3}^{5} - (\text{"1"})^2$ | M1 |
| | $\text{Var}(X) = \frac{16}{3}$ | A1 |
| | | (3) |

| | Notes | | Total 12 |
|---|---|---|---|
| (a) | **M1** | For writing or using F(5) = 1 **or** F(5) – F(-3) = 1 **or** substituting $x=5$ **and** $k=\frac{1}{8}$ into F($x$) and showing it equals 1 . | |
| | **A1*** | Fully correct solution with at least $8k = 1$ seen then leading to a statement that $k=\frac{1}{8}$ | |
| (b)(i) | **M1** | For using 1 – F(2) / 1 – (F(2) – F(-3)) or $\int_{[2]}^{[5]}\frac{1}{8}\,dx = \left[\frac{x}{8}\right]_{[2]}^{[5]}$ (no limits needed) | |
| | **A1** | $\frac{3}{8}$ or exact equivalent | |
| (ii) | **B1** | Cao | |
| (c) | **M1** | Attempt to differentiate given F($x$) , at least one . (Can be implied by 1st A1) | |
| | **A1** | For $f(x)=\frac{1}{8}$ or $f(x)=k$ with the correct interval stated (condone <, but must be consistent) | |
| | **A1** | Fully correct (fully correct distribution (including the f ($x$)) implies 3/3) ) (Accept if left in $k$) | |

| | | |
|---|---|---|
| (d) | **B1** | Allow rectangular (distribution). (Allow $X \sim U\left(-3,5\right)$ or $X \sim Uniform\left(-3,5\right)$ )<br>Discrete – B0 |
| (e)(i) | **B1** | cao |
| (ii) | **M1** | use of $\frac{\left(\beta-\alpha\right)^2}{12}$ or $\left[\frac{x^3}{3}\text{"f}(x)\text{"}\right]_{-3}^{5}-\left(\text{"1"}\right)^2$ , (follow through a constant f($x$)) |
| | **A1** | $\frac{16}{3}$ or exact equivalent (Correct answer only 2/2) |

| Question Number | Scheme | Marks |
|---|---|---|
| 3(a) | Poisson/Po/Poiss with ($\lambda =$) 8.5 or $[X \sim]\text{Po}(8.5)$ (o.e) | B1 |
| | | (1) |
| (b) | **Cars** pass the junction **singly/randomly/independently**/at a **constant** (mean/average **rate**) | B1 |
| | | (1) |
| (c) | $\text{P}(X < 3) = \text{P}(X \leqslant 2) = 0.0093$ (calc 0.00928…) **awrt 0.0093** | B1 |
| | $\text{P}(5 < X < 11) = \text{P}(X \leqslant 10) - \text{P}(X \leqslant 5) = 0.7634 - 0.1496$ | M1 |
| | $= 0.6138$ (calc 0.6137…) **awrt 0.614** | A1 |
| | | (3) |
| (d) | N(255, 255) | M1 |
| | $[\text{P}(X > 280) =]\text{P}\left(Z > \frac{280.5 - \text{"}255\text{"}}{\sqrt{\text{"}255\text{"}}}\right)$ or $[\text{P}(X > 280) =]\text{P}\left(Z > \frac{\text{"}255\text{"} - 280.5}{\sqrt{\text{"}255\text{"}}}\right)$<br>$\Rightarrow [= \text{P}(Z > \pm\text{"}1.596...\text{"})]$ | M1M1 |
| | $= 0.0548$ ((Calc: 0.055147…)) **awrt 0.0548 – awrt 0.0552** | A1 |
| | | (4) |
| (e) | $\text{H}_0 : \lambda = 4.25 \quad \text{H}_1 : \lambda < 4.25$ **Allow 8.5** | B1 |
| | | (1) |
| (f) | $[\text{P}(X \leqslant 3)] =$ awrt 0.0301 **or** $[\text{P}(X \leqslant 4)] =$ awrt 0.0744 | M1 |
| | $X \leqslant 3$ | A1 |
| | | (2) |
| (g) | 5 is not in the critical region/Do not reject $\text{H}_0$ | M1 |
| | Insufficient evidence to suggest /prove that the **mean rate** of cars passing the junction has **decreased (o.e)** | A1ft |
| | | (2) |
| | **Notes** | **Total 14** |

| | | |
|---|---|---|
| (a) | **B1** | For Poisson / Po and 8.5 e.g. Po(8.5), (Condone Poisson/Po with mean 8.5). P(8.5) B0 |
| (b) | **B1** | For a correct assumption (must have the context of cars, and bolded words). |
| (c) | **B1** | awrt 0.0093 (Calc: 0.00928…) |
| | **M1** | For writing or using $\text{P}(X \leqslant 10) - \text{P}(X \leqslant 5)$ (o.e) May be implied by awrt 0.614 |
| | **A1** | awrt 0.614 (Calc: 0.61376…) |
| (d) | **M1** | Writing or using $\text{N}(255, 255)$. (Implied by the standardisation $\frac{x - 255}{\sqrt{255}}$) |
| | **M1** | Standardising with ( 279.5 / 280 / 280.5 ) **,** their mean **and** standard deviation. |
| | **M1** | Correct continuity correction seen ( 279.5 or 280.5 ) |
| | **A1** | awrt 0.0548 – awrt 0.0552 (Calc: 0.055147…) (**NB exact Poisson is 0.05687 and scores 0/4)** |
| (e) | **B1** | For correct hypotheses and attached to $\text{H}_0$ and $\text{H}_1$ in terms of $\lambda$ or $\mu$. (Allow 8.5) |
| (f) | **M1** | Either $[\text{P}(X \leqslant 3)] =$ awrt 0.0301 or $[\text{P}(X \leqslant 4)] =$ awrt 0.0744.<br>Implied by a correct CR coming from correct working.<br>If a two-tail critical region is being calculated award M1 for $X \leqslant 3$ seen, ignore upper tail |
| | **A1** | For a correct critical region (o.e) e.g. $X \leqslant 3$, $X < 4$, $0 \le X \le 3$, $0 < X \le 3$, $0 < X < 4$ etc<br>Do not allow if written as a probability statement. Allow any letter. Accept $CR \leqslant 3$ (o.e) |

| | | |
|---|---|---|
| | | Correct answer only (2/2) |
| (g) | **M1** | Follow through their CR. Correct non contextual statement (ignore any comparison of numbers). Don't allow contradictory statements. Implied by a correct contextual statement.<br>(Condone acceptance region) |
| | **A1ft** | Correct contextual statement in context, contains words in bold (o.e).<br>Must have an idea of rate.<br>(Condone councillor officer claim (the number of cars passing the junction during a 2-minute period) is incorrect o.e.)<br>Insufficient evidence to suggest that there are fewer cars passing **each minute / per minute (o.e)** is fine<br>(Sufficient evidence to suggest that) the rate is **8.5** cars every **2 minutes** \ **4.25** cars **every 1 minutes** (o.e) |

| Question Number | Scheme | Marks |
|---|---|---|
| 4(a) | $0.25\times £5+0.4\times £6+0.35\times £7$ (o.e) | M1 |
| | $=[£]6.10$ | A1 |
| | | (2) |
| (b) | 5 5 5    6 6 6    7 7 7<br>5 5 6 (*x*3)    6 6 7 (*x*3)    6 7 7 (*x*3)<br>5 5 7 (*x*3)    5 6 6 (*x*3)    5 7 7 (*x*3)<br>5 6 7 (*x*6) | B1B1 |
| | | (2) |
| (c) | P(5) = 0.25    P(6) = 0.4    P(7) = 0.35 | B1 |
| | Range can be 0, 1, or 2 | B1 |
| | $[\mathrm{P}(R=0)]=0.25^3+0.4^3+0.35^3=\frac{49}{400}$ | M1 |
| | $[\mathrm{P}(R=1)]=0.25^2\times 0.4\times 3+0.4^2\times 0.35\times 3+0.4\times 0.35^2\times 3+0.25\times 0.4^2\times 3=\frac{51}{100}$ | M1 |
| | $[\mathrm{P}(R=2)]=0.25^2\times 0.35\times 3+0.25\times 0.35^2\times 3+0.25\times 0.4\times 0.35\times 6=\frac{147}{400}$ | M1 |
| | <table><tr><td>$r$</td><td>0</td><td>1</td><td>2</td></tr><tr><td>$\mathrm{P}(R=r)$</td><td>$\frac{49}{400}$<br>(0.1225)</td><td>$\frac{51}{100}$<br>(0.51)</td><td>$\frac{147}{400}$<br>(0.3675)</td></tr></table> | A1 |
| | | (6) |

| | Notes | | Total 10 |
|---|---|---|---|
| (a) | **M1** | For $0.25\times £5+0.4\times £6+0.35\times £7$ (o.e) (May be implied by a correct answer) | |
| | **A1** | [£] 6.10 (allow 6.1) | |
| | **Part b)** | If combinations not given in b), award the B marks, if the combinations are seen in c) | |
| (b) | **B1** | For 8 of the 10 possible combinations (Ignore repeats).<br>(Condone if they sum the combinations, combinations need to be seen) | |
| | **B1** | All possible 10 combinations given (Ignore repeats).<br>(Condone if they sum the combinations, combinations need to be seen) | |
| (c) | **B1** | All three probabilities written or used (may be seen in an equation in c) or implied by a correct probability) | |
| | **B1** | All three ranges and no extras (may see these in the table) Need to be ranges | |
| | **M1** | A correct method for $\mathrm{P}(R=0)$ (implied by $\frac{49}{400}$ (o.e) or exact equivalent, may be in table)) | |
| | **M1** | A correct method for $\mathrm{P}(R=1)$ (implied by $\frac{51}{100}$ (o.e) or exact equivalent, may be in table)) | |
| | **M1** | A correct method for $\mathrm{P}(R=2)$ (implied by $\frac{147}{400}$ (o.e) or exact equivalent, may be in table))<br>**or** their 3 probabilities sum to 1 | |
| | **A1** | fully correct with probabilities or exact equivalents. (Need not be in a table but must be attached to the correct range. (Fully correct with no incorrect working implies 6/6) | |

| Question Number | Scheme | Marks |
|---|---|---|
| 5(a)(i) | B(20, 0.45) | |
| | $[\mathrm{P}(X=6)] = {}^{20}\mathrm{C}_6 \times 0.45^6 \times 0.55^{14} = 0.0746$ ((Calc: 0.074599… ) **awrt 0.0746** | M1 A1 |
| (ii) | B(30, 0.2) | |
| | $[\mathrm{P}(X \geqslant 12)] = 1 - \mathrm{P}(X \leqslant 11) = 1 - 0.9905$ | M1 |
| | = 0.0095 (Calc: 0.00949…)) **awrt 0.0095** | A1 |
| | | (4) |
| (b) | $\sqrt{10p(1-p)} = 1.5$ | M1 |
| | $10p^2 - 10p + 2.25 = 0$ (o.e) | M1 |
| | $p$ = awrt 0.658 **and** $p$ = awrt 0.342 | A1 |
| | Mean = $np$ So mean $= 10 \times "0.3418..."$ **or** mean $= 10 \times "0.6581..."$ | M1 |
| | = awrt 3.42 and awrt 6.58 | A1 |
| | | (5) |
| (c) | As the probability of completing a **medium** trick is 0.45 you would expect the probability of completing an **easy** trick to have a higher probability (0.6581…) (o.e) | M1 |
| | So most likely value is awrt 6.58 | A1 |
| | | (2) |
| (d) | $\mathrm{H}_0 : p = 0.2$ $\mathrm{H}_1 : p > 0.2$ | B1 |
| | $[\mathrm{P}(X \geqslant 10) = 1 - \mathrm{P}(X \leqslant 9)] = 1 - 0.9389$ or<br>$[\mathrm{P}(X \geqslant 11) = 1 - \mathrm{P}(X \leqslant 10)] = 1 - 0.9744$ | M1 |
| | = 0.0611 or CR: $X \geqslant 11$ or $X > 10$ (o.e) | A1 |
| | Do not reject $\mathrm{H}_0$/Not in CR/Not significant | M1 |
| | Insufficient evidence to support **Paula's or her belief (o.e)** \ Insufficient evidence to suggest that the **probability** of completing a **hard trick** successfully has **increased** (o.e) | A1ft |
| | | (5) |
| | **Notes** | **Total 16** |

| | | |
|---|---|---|
| (a)(i) | **M1** | Correct method to finding $\mathrm{P}(X=6)$. Allow equivalent expressions.<br>Using $P(X <= 6) - P(X <= 5)$ M1. May be implied by awrt 0.0746 |
| | **A1** | awrt 0.0746 (Calc: 0.074599… ). |
| (ii) | **M1** | For writing or using $1 - \mathrm{P}(X \leqslant 11)$ (Implied by $1 - 0.9905$ ) |
| | **A1** | awrt 0.0095 (Calc: 0.00949…) (Correct answer 2/2) |
| (b) | **M1** | For use of $\sqrt{np(1-p)} = 1.5$ or $\sqrt{np(1-p)} = \sigma$ |
| | **M1** | Correct three-term quadratic $10p^2 - 10p + 2.25 = 0$ (o.e) |
| | **A1** | $p$ = awrt 0.658 **and** $p$ = awrt 0.342. condone ( $p = \dfrac{10+\sqrt{10}}{20}$ and $p = \dfrac{10-\sqrt{10}}{20}$ )<br>(Correct values seen with no incorrect working seen M1M1A1) |
| | **M1** | Use of mean = $np$ , (Follow through their $p$ values ( $0 \le p \le 1$ )) |
| | **A1** | awrt 3.42 and awrt 6.58 or condone ( $\dfrac{10+\sqrt{10}}{2}$ and $\dfrac{10-\sqrt{10}}{2}$ ) |

| | | |
|---|---|---|
| (c) | **M1** | Identifying 'their' probability of an **easy** trick must greater than 0.45 \ has larger probability than a **medium** trick (o.e)<br>They must be comparing 'their' probability of an easy trick with 0.45 \ probability of a medium trick<br>Must be 6.58 (or surd form) since using 0.348 would mean an **easy** trick is harder than a **medium** trick M1A1 |
| | **A1** | identifying awrt 6.58 condone ( $p = \dfrac{10+\sqrt{10}}{2}$ ) |
| (d) | **B1** | For correct hypotheses and attached to $H_0$ and $H_1$ in terms of $p$ or $\pi$ |
| | **M1** | Use of either $1-\mathrm{P}(X \leqslant 9)$ or $1-\mathrm{P}(X \leqslant 10)$ (calculating **just** $\mathrm{P}(X=10)$ M0).<br>(Implied by awrt 0.0611 or 0.0256) |
| | **A1** | awrt 0.0611 or critical region : $X \geqslant 11$, $X > 10$ (o.e), (Condone 0.9389 < 0.95 o.e) |
| | **M1** | A correct non contextual statement. Do not allow contradictory statements.<br>May be implied by a correct contextual statement on its own. (0.0256/0.0355 and comparing to 0.05 is M0. Follow through their probability / critical region. |
| | **A1ft** | correct contextual statement using the bolded word (o.e).<br>Don't accept chance as an alternative to probability. |

| Question Number | Scheme | Marks |
|---|---|---|
| 6(a) | $\frac{9}{10}np = np(1-p) \Rightarrow 0.9 = 1-p$ | M1 |
| | $p = 0.1$ | A1 |
| | | (2) |
| (b) | $\frac{e^{-\lambda}\lambda^{19}}{19!} = \frac{e^{-\lambda}\lambda^{20}}{20!}$ | M1 |
| | $\frac{20!}{19!} = \frac{\lambda^{20}}{\lambda^{19}}$ | M1 |
| | $\lambda = 20$ | A1 |
| | $np = \lambda \quad \Rightarrow \quad n = \frac{"20"}{"0.1"}$ | M1 |
| | $n = 200$ | A1 |
| | | (5) |
| (c) | **Reasonable (o.e)** as $n$ is large and $p$ is small | B1 |
| | | (1) |
| | **Notes** | **Total 8** |

| | | |
|---|---|---|
| (a) | **M1** | Use $\frac{9}{10}np = np(1-p)$ leading to an equation in $p$ only |
| | **A1** | 0.1 (correct answer with no incorrect working seen 2/2) |
| (b) | **M1** | For $\frac{e^{-\lambda}\lambda^{19}}{19!} = \frac{e^{-\lambda}\lambda^{20}}{20!}$ (Allow if 0.1n has been used for $\lambda$). (Condone if no brackets seen) |
| | **M1** | Cancelling $e^{-\lambda}$ |
| | **A1** | $\lambda = 20$ or 0.1n=20 (Correct value seen M1M1A1) (Implied by $n$=200) |
| | **M1** | Use of $np = \lambda$. Follow through their $\lambda$ / 0.1$n$ and $p$ ($p$ must be a probability) |
| | **A1** | $n$ = 200 (correct answer seen with no incorrect working (5/5)) |
| (c) | **B1** | Reasonable (o.e) and a correct reason<br>(allow Reasonable as mean is approximately equal to the variance (Sight of 18 needed)) |

| Question Number | Scheme | Marks |
|---|---|---|
| 7(a) | $\frac{1}{2}k(2k-3)=1$ | M1 |
| | $k^2-\frac{3}{2}k-1=0$ (o.e) so $(k-2)(2k+1)=0 \Rightarrow k=2$ | A1* |
| | | (2) |
| (b) | [Mode] = 4 | B1 |
| | | (1) |
| (c) | Gradient = 2 so $y=2x+c$ Goes through (3, 0) so $c=-6$ | M1 |
| | $\mathrm{f}(x)=\begin{cases}2x-6 & 3\leqslant x\leqslant 4\\ 0 & \text{otherwise}\end{cases}$ | dM1 A1 |
| | | (3) |
| (d) | $\mathrm{E}\left(X^2\right)=\int_{[3]}^{[4]}x^2\left(2x-6\right)\mathrm{d}x$ | M1 |
| | $=\left[\frac{1}{2}x^4-2x^3\right]_3^4$ | dM1 |
| | $=\left(128-128\right)-\left(\frac{81}{2}-54\right)\left[=\frac{27}{2}\right]$ | M1 |
| | $\mathrm{Var}(X)=\text{"}\frac{27}{2}\text{"}-\left(\frac{11}{3}\right)^2$ | M1 |
| | $=\frac{1}{18}$ | A1 |
| | | (5) |

| | | **Notes** | **Total 11** |
|---|---|---|---|
| (a) | **M1** | for use of area = 1 or using $k$=2 and showing the area = 1 | |
| | **A1** | for a correct three term quadratic = 0 or a correct method to find $k$ e.g. $(k-2)(2k+1)=0$ **and** a statement that $k$ = 2 (must reject $k$=-0.5 if stated).<br>If they have shown by verification that the area = 1, we also need a statement $k$ = 2.<br>Correct answer with no incorrect working seen (2/2). | |
| (b) | **B1** | 4 (Condone $2k$) | |
| (c) | **M1** | for either $y=2x+c$ or $y=ax-6$ with $a>1$ or $y-2=m(x-4)$, $m>1$ | |
| | **dM1** | for their f($x$) = $2x-6$ associated with the correct range, dep on 1st M1 (condone < but must be consistent) | |
| | **A1** | fully correct (Correct answer 3/3) | |
| (d) | **M1** | for $\int x^2\mathrm{f}(x)\,\mathrm{d}x$ (Condone missing d$x$ or use of another letter), Ignore limits. Using their f($x$) but must be an equation of a line. We must see f($x$) in the integral so just seeing $\int x^2\,\mathrm{d}x$ - M0 | |
| | **dM1** | Dep of 1st M1, for an integration using their f($x$) (at least 1 term $x^n \to x^{n+1}$). Condone upper limit as $2k$ | |
| | **M1** | for correct substitution of limits seen (3 and 4 ($2k$)) into their integration.<br>Check unseen substitution for a single term. | |
| | **M1** | for a correct method to find the variance. ft their 13.5 Var(X)<0 or $\mathrm{E}\left(X^2\right)<0$ is M0 | |
| | **A1** | $\frac{1}{18}$ or exact equivalent | |