Question	Scheme	
1 (a)	0.85	B1
		(1)
(b)	$3X-3<X+2\rightarrow X<2.5$	M1
	$[\mathrm{P}(X<2.5)=]$ 0.5	A1
		(2)
(c)	$[\mathrm{E}(X)=]1\times0.3+2\times0.2+3\times0.35+4\times0.15=$	M1
	2.35	A1
		(2)
(d)	$\left[\mathrm{E}\left(X^2\right)=\right]1^2\times0.3+2^2\times0.2+3^2\times0.35+4^2\times0.15\left[=6.65\right]$	M1
	$[\mathrm{Var}(X)=]$"6.65"−"2.35"^{2}	M1
	= 1.1275*	A1*
		(3)
(e)	$\left[\mathrm{Var}\left(5-2X\right)=\right]$ 4.51	B1
		(1)
		Total 9
	Notes	
	Look out for answers given next to the questions	
(a)	B1 oe Must be identified as answer to part (a) (not just seen anywhere in the script). Ignore their label.	
(b)	M1 for $X < 2.5$ (condone $X > 2.5$, $X = 2.5$) <u>or</u> $X \leq 2$ <u>or</u> for identifying $X = 1$ and $X = 2$ (may be circled, ticked, or otherwise clearly identified as the only 2 x-values that satisfy the inequality) <u>or</u> 0.3 + 0.2	
	A1 oe Correct answer scores 2 out of 2.	
(c)	M1 for an attempt to find E(X) with at least 3 correct products or terms with intention to add 0.3 + 0.4 + 1.05 + 0.6 (may be seen in table at the start of the question) Division by 4 or any k ($k \neq 1$) is M0	
	A1 oe Correct answer scores 2 out of 2	
(d)	M1 for an attempt to find E(X^2) with at least 3 correct products or terms with intention to add 0.3 + 0.8 + 3.15 + 2.4 (may be seen in table at the start of the question or elsewhere) Division by 4 or any k ($k \neq 1$) is M0 6.65 on its own does not imply this mark	
	M1 for $6.65 - 2.35^2$ ft their E(X) and E(X^2). A full calculation scores M1M1 e.g. $1^2\times0.3+2^2\times0.2+3^2\times0.35+4^2\times0.15-5.5225$	
	A1*cso dependent on both M marks for a fully correct expression for Var(X) leading to correct given answer 1.1275 with no incorrect working seen. $6.65-2.35^2$ = 1.1275 on its own scores M0M1A0	
(e)	B1 for 4.51 oe	

Question	Scheme	
2(a)	$\left[\sum x_B =\right] 54\times 45 - 24\times 47 \left[=1302\right]$ or $\frac{24\times 47 + 30b}{54} = 45$	M1
	$\left[\bar{x} =\right] \frac{54\times 45 - 24\times 47}{30} = 43.4$ *	A1*
		(2)
(b)	$\sqrt{\frac{66876+73826}{54} - 45^2} =$ or $\sqrt{\frac{(66876+73826) - \frac{2430^2}{54}}{54}}$	M1
	24.095…. awrt 24.1	A1
		(2)
(c)(i)	No effect as e.g. adding 2 to each does not change the variance	B1
(ii)	Increase as e.g. the total mark will increase	B1
(iii)	Decrease as e.g. the mean mark of class *B* is closer to the mean mark of class *A*	B1
		(3)
	Notes	**Total 7**
(a)	M1 for a correct method to find the total marks for class *B* or for a correct equation for *b* eg 1128 + 30*b* = 2430 but not 30*b* = 1302 on its own	
	A1* a fully correct method shown leading to 43.4 For the equation in *b* there should be 1 line of intermediate working between the equation and the given answer.	
SC:	Verification method e.g. $\frac{24\times 47 + 30\times 43.4}{54} = 45$ scores M1A0	
(b)	M1 for a correct method to find the standard deviation including root	
	A1 awrt 24.1 correct answer scores 2 out of 2 allow *s* = awrt 24.3	
(c)(i)	B1 for no effect **and** a correct reason: • Spread/variation/range or difference (in marks) remains the same o.e. • Addition has no effect/only multiplication/division affects the variance o.e. Variance not affected by coding on its own is B0	
(ii)	B1 for increase **and** a correct reason: • Total/mark/score/$\sum x$ increases o.e. • Mean of class *B* increases (by 2 marks) o.e. • Total/mark/score/$\sum x$ for class *B* increases (by 60 marks) o.e. Incorrect statements score B0 e.g. "The mean (of all 54 students) increases by 2" or e.g. "Total for class *B* increases by 48 marks" Ignore calculation if seen, but do **not** allow increases by 1.11…. on its own to score the mark here.	
(iii)	B1 for decrease **and** correct reason: • Mean/marks of class *B* now closer to mean/marks of class *A* o.e. • Values/marks/scores are closer together o.e. • Less spread/variation between values/marks/scores (for class *A* and class *B*) o.e.	

Question	Scheme	
3 (a)	eg They represent / analyse / solve (real world problems)	B1
	They improve understanding / simplify (the real world)	
	Can be repeated/ adapted / refined	
	To show the relationship between variables/show trends	
		(1)
(b)	$[S_{ww} =]10036.45 - \frac{339.25^2}{12} = 445.57$ (to 2 decimal places)*	B1*
		(1)
(c)	$S_{td} = \frac{-91.55}{11.5}$ or $S_{td} = 14.4 - \frac{29.5 \times 9.1}{12}$ or $S_{dd} = \frac{445.57}{11.5^2}$ or $S_{dd} = 75.9 - \frac{29.5^2}{12}$	M1
	$S_{td} = -7.9608...$ awrt **$\underline{-7.96}$** $S_{dd} = 3.3691...$ awrt **$\underline{3.37}$**	A1A1
		(3)
(d)	$[r =]\frac{-91.55}{\sqrt{445.57 \times 26.43}}$ or $[r =]\frac{"-7.9608..."}{\sqrt{"3.3691..." \times 26.43}}$	M1
	$= -0.8436\ldots$ awrt **$\underline{-0.844}$**	A1
		(2)
(e)	As the **temp**erature increases, **gas/consumption** decreases	B1ft
		(1)
(f)	$b = \frac{-91.55}{26.43}$ [$= -3.4638\ldots$]	M1
	$a = \frac{339.25}{12} - "-3.4638" \times \frac{9.1}{12}$ [$= 30.897\ldots$] or $a =$ awrt $28.3 - "-3.4638" \times$ awrt 0.76	M1
	$w = -3.46t + 30.9$ *	A1*
		(3)
(g)	$11.5d = -3.46t + 30.9$ oe eg $d = -0.301t + 2.69$	B1
		(1)
(h)(i)	$2.0852\ldots$ (m^3) awrt **$\underline{2.09}$**	B1
(ii)	the gas consumption will **decrease** by **0.3 m^3**	B1ft
		(2)
		Total 14

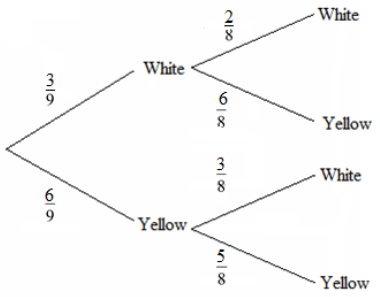
(a)	B1 for one valid reason why models are used B0 for comments relating to **time**, **cost**, and **predictions** only. **"**Easy"/ "Easy to use" on its own is B0 Ignore extraneous non-contradictory comments once B1 has been scored.
(b)	B1* Correct numerical method to find S_{ww} shown with an answer awrt 445.57
(c)	M1 Method to find S_{dd} or S_{td} (implied by awrt −7.96 or awrt −7.97 or awrt 3.37 or awrt 3.38)
	A1 awrt −7.96 **$\underline{\text{or}}$** awrt 3.37 condone awrt −7.97 **$\underline{\text{or}}$** awrt 3.38 for this mark
	A1 awrt −7.96 **$\underline{\text{and}}$** awrt 3.37
(d)	M1 for a correct method with $S_{ww} \neq 10036.45$
	A1 awrt –0.844 correct answer scores 2 out of 2 an answer of awrt –0.843 scores M1A0
(e)	B1ft for correct contextual interpretation with bold words o.e., ft "their (d)" Allow as **gas** increases, **temp(**erature) decreases o.e. B0 for "their (d)" outside the range [–1, 1] Interpreting numerically as a gradient is B0.
(f)	M1 for a correct numerical expression to find the value of b
	M1 for a correct method to find a allow "their b" or just b in the expression $w -$ awrt $28.3 = "-3.46..."(t -$ awrt $0.76)$
	A1* (dep on M1M1) for correct given equation. Allow $w =$ awrt $-3.46t +$ awrt 30.9 No fractions.
(g)	B1 Any correct equation seen (ISW) (allow fractions). allow $d = -0.3t + 2.69$, $d = \frac{-3.46t+30.9}{11.5}$
(h)(i)	B1 awrt 2.09
(ii)	B1ft for decrease awrt 0.3m^3 must include units ft their changed gradient B0 for decrease by –0.3m^3

Question	Scheme	
4 (a)	$0.2=\dfrac{\mathrm{P}(C\cap D)}{0.45}$	M1
	[$\mathrm{P}(C\cap D)$ =] 0.09	A1
		(2)
(b)	$0.59=\mathrm{P}(C)+0.45-"0.09"$ $[\rightarrow \mathrm{P}(C)=0.59-0.45+"0.09"]$	M1
	= 0.23	A1
		(2)
	Notes	**Total 4**
	Mark (a) and (b) together	
(a)	M1 for substitution of 0.2 and 0.45 into a correct equation for $\mathrm{P}(C\cap D)$ (allow any rearrangement)	
	A1 oe correct answer scores 2 out of 2 Must be clearly identified as the answer to part (a). A correct Venn diagram on its own is not sufficient.	
(b)	M1 for correct substitution of 0.59, 0.45 and "their a" into $\mathrm{P}(C\cup D)=\mathrm{P}(C)+\mathrm{P}(D)-\mathrm{P}(C\cap D)$ Implied by "their (b)" – "their(a)" = 0.14 $0.59=\mathrm{P}(C)+0.45$ is M0 Only ft 0 < "their (a)" < 1 If "their (a)" is outside this range, then M0	
	A1 oe correct answer scores 2 out of 2	

Question	Scheme	
5 (a)	**Speed (km/h)** | **Number of cars** | **fd** $20 \le x < 25$ | 54 | 10.8 $25 \le x < 30$ | 90 | 18 $30 \le x < 40$ | 60 | 6	M1
	$90x = 54 \times 10$ or $18x = 10.8 \times 10$	M1
	height of 2nd tallest bar = 6 (cm)	A1
		(3)
(b)	$30 + 15 + \frac{2}{15} \times 6$ = 45.8 , therefore **<u>46</u>** cars.	M1, A1
		(2)
(c)	$\left[Q_2 = 25 + \right] \frac{58.5}{90} \times 5$	M1
	= 28.25 awrt **<u>28.3</u>**	A1
		(2)
(d)(i)	$\left[Q_3 = 30 + \right] \frac{24.75}{60} \times 10$	M1
	= 34.125 awrt **<u>34.1–34.3</u>**	A1
(ii)	"34.125" – 25.14	M1
	= 8.99 awrt **<u>9.0 – 9.1</u>**	A1
		(4)
(e)	$Q_2 - Q_1 (3.11) < Q_3 - Q_2 (5.875)$	M1
	therefore, positively skewed	A1
		(2)
(f)	The suggestion is **not suitable** as part (e) shows the data is **skewed/not symmetric**.	B1ft
		(1)
		Total 14

(a)	M1 for evidence of fd = f/w <u>or</u> for identifying/using $25 \le x < 30$ as the tallest bar <u>or</u> $20 \le x < 25$ as the 2nd tallest bar <u>or</u> an answer of awrt 3.33
	M1 identifying/using $25 \le x < 30$ as the tallest bar **and** $20 \le x < 25$ as the 2nd tallest bar. Implied by correct working seen or correct answer. Allow equivalent ratio equation.
	A1 6 cao Be careful the f.d. of the 3rd bar is 6, so 60 ÷ 10 = 6 on its own is M1M0A0. Answer only scores M1M0A0
(b)	M1 for $30 + 15 + k$ where $0.5 \le k \le 1$ (implied by 45.8) or $k + 219 - (54 + 90 + 30)$
	A1cao 45 or 46 (must be an integer). Correct answer only scores 2 out of 2.
(c)	M1 for $\frac{58.5}{90} \times 5$ or $\frac{m - 25}{112.5 - 54} = \frac{30 - 25}{144 - 54}$ or $\frac{31.5}{90} \times 5$ or $\frac{30 - m}{144 - 112.5} = \frac{5}{90}$ Allow use of 113 instead of 112.5
	A1 for awrt 28.3
(d)(i)	M1 for $\frac{24.75}{60} \times 10$ or $\frac{Q_3 - 30}{168.75 - 144} = \frac{40 - 30}{204 - 144}$ or $\frac{35.25}{60} \times 10$ or $\frac{40 - m}{204 - 168.75} = \frac{10}{60}$ Allow use of any value from 168.75 to 169.5
	A1 awrt 34.1 to awrt 34.3 an answer in this range scores 2 out of 2 unless obvious incorrect working
(ii)	M1 for "their (d)(i)" substituted into "Q_3" – awrt 25.1
	A1 awrt 9.0 or awrt 9.1 Allow 9 if correct working seen.
(e)	M1 A correct comparison which must follow from their figures. Must have 25.14 < " Q_2"< "Q_3"
	A1 dep on M1 **and** dep on their figures being consistent with positive skew. Negative skew is A0. Allow calculation of estimated mean awrt 30.6 > "28.3" so +ve for M1A1
(f)	B1ft For not suitable **and** a correct supporting reason which is consistent with "their (e)"

Question	Scheme	
6(a)(i)	$P(X > 508) = P\left(Z > \frac{508-502}{3}[=2]\right)$	M1
	= 0.0228 awrt 0.0228	A1
		(2)
(ii)	$P(496 < X < 508) = 1 - 2 \times "0.0228"$ or $"0.9772" - (1 - "0.9772")$	M1
	= 0.9544 awrt 0.954	A1ft
		(2)
(b)	$"0.0228"^2 \times (1 - "0.0228")^2 \times 6$	M1 dM1
	= 0.002978… (calc gives 0.002965…) awrt **0.00297** or awrt **0.00298**	A1
		(3)
(c)	$\frac{1038.51-1024}{\sigma} = 1.0364$	M1
	$\sigma = \frac{1038.51-1024}{1.0364} = 14.000..$ (calc 13.999…)*	A1*
		(2)
(d)(i)	$\pm\left(\frac{k-502}{3}\right)$ **and** $\pm\left(\frac{1024-2k}{14}\right)$	M1
	$\frac{k-502}{3} = \frac{1024-2k}{14}$ oe e.g. $14k - 7028 = 3072 - 6k$	M1
	$k = 505$	A1
(ii)	$P(X > 505) = P\left(Z > \frac{"505"-502}{3}[=1]\right)$	M1
	= 0.1587 awrt **0.159**	A1
		(5)
	Notes	**Total 14**
(a)(i)	M1 for standardising with 508, 502 and 3 allow ±	
	A1 awrt 0.0228 (dependent on M1 scored for standardising) . Answer must be in part (a)(i).	
(ii)	M1 ft their 0.0228	
	A1ft awrt 0.954 or from calculator 0.954499…. so allow 0.9545 Correct answer scores 2 out of 2. ft their part (a) i.e. 1 – 2 × "their (a)" provided 0 < "their (a)" < 0.5	
(b)	M1 For an expression in the form $p^2 \times (1-p)^2 \times A$ where A is an integer, $A \ldots 1$ and p is a probability Allow A written in alternative forms eg ${}^4C_2$	
	M1 dep on first M1 for $A = 6$ oe	
	A1 awrt 0.00297 or awrt 0.00298 (allow in standard form). Correct answer scores 3 out of 3.	
(c)	M1 an equation in the form $\frac{1038.51-1024}{\sigma} = z$ or $\frac{14.51}{\sigma} = z$ with 1.03,, $\lvert z \rvert$,, 1.04	
	A1* for a correct expression for σ with z = 1.0364 or better (calc 1.036433…) seen and awrt 14	
(d)(i)	M1 for both standardisations seen or used in an equation Allow use of their 14 from part (c)	
	M1 Correct equation with compatible signs - need not be simplified Allow use of their 14 from part(c)	
	A1 505 (allow awrt 505 coming from "their 14" used).	
(ii)	M1 for standardising with "505", 502 and 3 or with "1010", 1024 and 14 allow ±, ft their value of k may be implied by a correct answer	
	A1 awrt 0.159 Correct answer scores M1A1 in (d)(ii)	

Question Number	Scheme	
7(a)		B1 M1A1 (3)
(b)	$"\frac{3}{9}"\times"\frac{6}{8}"+"\frac{6}{9}"\times"\frac{3}{8}"$, $=\frac{1}{2}$ oe	M1, A1 (2)
(c)	$1-"\frac{6}{9}"\times"\frac{5}{8}"$ or $"\frac{3}{9}"+"\frac{6}{9}"\times"\frac{3}{8}"$, $=\frac{7}{12}$ oe	M1, A1 (2)
(d)	$\frac{"\frac{3}{9}"\times"\frac{2}{8}"}{"\frac{7}{12}"}$, $=\frac{1}{7}$ oe	M1, A1 (2)
(e)	$\frac{\frac{1}{2}n}{n}\times\frac{\frac{1}{2}n-1}{n-1}\times\frac{\frac{3}{8}n}{n-2}\times\frac{\frac{1}{8}n}{n-3}=\frac{3}{235}$ | $\frac{4x}{8x}\times\frac{4x-1}{8x-1}\times\frac{3x}{8x-2}\times\frac{x}{8x-3}=\frac{3}{235}$	M1M1
	$\frac{3}{128}n^3(\frac{1}{2}n-1)=\frac{3}{235}n(n-1)(n-2)(n-3)\left[\rightarrow 63n^3-3198n^2+8448n-4608=0\right]$	dM1
	$\left[235n^2=256(n-1)(n-3)\Rightarrow\right]21n^2-1024n+768=0$ **or** $\left[(3n-6)(21n^2-1024n+768)\right]$ $\left[\Rightarrow(n\neq 2\therefore)\right]21n^2-1024n+768=0$	A1
		(4)
	Notes	**Total 13**
(a)	B1 1st branches correct oe allow $0.\dot{3}$ and $0.\dot{6}$	
	M1 for one correct 2nd branch 2/8 and 6/8 oe or 3/8 and 5/8 oe	
	A1 for both correct 2nd branches 2/8 and 6/8 and 3/8 and 5/8 oe	
(b)	M1 for adding the two correct products of probabilities ft their probabilities	
	A1 0.5 oe Correct answer from no obvious incorrect working scores M1A1	
(c)	M1 correct method used. ft their probabilities	
	A1 allow awrt 0.583	
(d)	M1 for $\frac{p}{"7/12"}$ or $\frac{n}{7}$ where $n < 7$. num>denom is M0. Indeped. e.g. $\frac{"\frac{3}{9}"\times"\frac{2}{8}"\times"\frac{7}{12}"}{"\frac{7}{12}"}$ is M0	
	A1 allow awrt 0.143	
(e)	M1 for setting up the product of 4 probabilities with all of the denominators correct and equating to 3/235 For the first term allow ½ oe (condone RHS method in terms of n)	
	M1 a fully correct equation (condone RHS method in terms of n)	
	dM1 (dep on 2nd M mark) for forming a correct equation **in terms of *n*** removing all terms in n from the denominator. For RHS method, only award if x is replaced by $\frac{n}{8}$	
	A1 (dep on all M marks) for a correct equation with $b = -1024$ and $c = 768$	
NB:	Trial and improvement method → $n = 48$ satisfies the given conditions is M0M0M0A0	