Qn	Scheme	Marks	AOs
1(a)	$S_{xy} = 604\,430 - 326 \times 1808$ $= 15022$	M1 A1	2.1 1.1b
	$r = \dfrac{15022}{10\sigma_x \times \sigma_y}$ (o.e.) $= 0.972\ldots$ (awrt 0.972)	M1 A1	1.1b 1.1b
		(4)	
(b)	H_0: $\rho = 0$ H_1: $\rho \neq 0$	B1	2.5
	Critical value is ± 0.6319	B1	1.1b
	As $r = 0.972$ it is significant at the 5% level, so reject H_0	M1	2.4
	There is evidence of correlation between size of shipment and overtime (o.e.)	A1	2.2b
		(4)	
			(8 marks)

Question 1 notes:
(a) M1: for correct expression for finding S_{xy} A1: for 15022 (allow 15000) M1: for substituting into a suitable formula for *r* A1: for awrt 0.972
(b) B1: for both hypotheses correct using correct notation B1: for correct critical value M1: for a correct non-contextual statement. (Do not allow contradicting non-contextual statements) A1: for suitable comment in context

Qn	Scheme	Marks	AOs
2(a)	$\mathbf{S_{xx} = 6486}$	B1	1.1b
	$b = \frac{6452}{6486} = 0.994757\ldots$	M1	3.3
	$a = \frac{783}{12} - b \times \frac{540}{12} =$ 20.48589…	M1	3.4
	$c = 20.5 + 0.995x$	A1	1.1b
		(4)	
(b)	For every extra lorry-load production costs increase by £99.50	B1 ft	3.4
	When there are no lorry-loads the production costs are £2050 (Overheads)	B1 ft	3.4
		(2)	
(c)	Residual = $c_i - \hat{c}_i = 89 - (20.5 + 0.995 \times 72)$ or $35 - (20.5 + 0.995 \times 12)$	M1	3.4
	$= -3.14$	A1	1.1b
	$= 2.56$	A1	1.1b
		(3)	
(d)	RSS = $S_{cc} - \frac{(S_{xc})^2}{S_{xx}}$ so need $S_{cc} = 6466.25$	B1	2.1
	$= 6466.25 - \frac{6452^2}{"6486"}$	M1	1.1b
	$= 48.0717\ldots$	A1	1.1b
		(3)	

(e)	Use of regression line with $x = 60$ gives costs of $c = 80.2$ and average residual is $\sqrt{\frac{48.07...}{12}} = 2$ so estimate 78.2 ~ 82.2 i.e. £7800 to £8200	M1 A1	3.4 1.1b
		(2)	
(f)	Model is linear so has a constant gradient so managing director's belief is <u>not</u> consistent with the model	B1	3.5ab
		(1)	
			(15 marks)

Question 2 notes
(a) B1: for $\mathbf{S_{xx} = 6486}$ M1: for use of $b = \frac{\mathbf{S_{xp}}}{\mathbf{S_{xx}}}$ i.e. choosing the correct linear moel M1: for use of $a = \bar{c} - b\bar{x}$ i.e. using the model to find the intercept A1: for b = awrt 0.995 and for a = 20.5 in a $c = a + bx$ equation
(b) B1 ft: for correct interpretation of the slope e.g. for every extra lorry-load production costs increase by £99.50 ft part (a) B1 ft: for correct interpretation of the intercept e.g. when there are no lorry-loads the production costs are £2050 ft part (a)
(c) M1: use of the model with a correct expression for either residual A1: for the residual when $x = 72$ of awrt – 3.14 A1: for the residual when $x = 12$ of awrt 2.56
(d) B1: for realising the need for S_{cc} and S_{cc} = 6466.25 (allow awrt 6470) M1: for a correct expression for RSS A1: for awrt 48.1
(e) M1: for use of regression line to get awrt 80.2 and realising average residual is $\pm$ 2 A1: for a range of £7800 to 8200 (approx.)
(f) B1: for realising that a linear model means constant gradient and so belief is <u>not</u> consistent with the model.

Qn	Scheme	Marks	AOs
3 (a)	z value = 1.6449	B1	3.4
	$1.21 \pm 1.6449 \times \frac{0.15}{\sqrt{80}}$	M1	1.1b
	$1.1824\ldots < \mu < 1.2375\ldots$	A1	1.1b
		(3)	
(b)	$\mathbf{H_0}: \mu_{Black} = \mu_{Red}$ $\mathbf{H_1}: \mu_{Black} \neq \mu_{Red}$	B1	2.5
	$z = \frac{1.21 - 1.25}{\sqrt{\frac{0.15^2}{80} + \frac{0.13^2}{75}}} = -1.7771\ldots$	M1 A1	2.1 1.1b
	5% critical value is ± 1.96	B1	1.1b
	– 1.78 is not in the critical region so not significant, so do not reject H_0	M1	2.4
	There is not sufficient evidence to suggest that the mean line lengths differ.	A1	2.2b
		(6)	
			(9 marks)

Question 3 notes:

(a)
B1: for correct z value
M1: for use of $\bar{x} \pm z \text{ value} \times \frac{s}{\sqrt{n}}$ (allow n = 75 as a slip)
A1: for awrt $1.18 < \mu <$ awrt 1.24

(b)
B1: for both hypotheses correct using correct notation
M1: for calculating correct z value (allow slip of switched n values)
A1: for awrt – 1.78 (allow ±)
B1: for correct critical value
M1: for a correct non-contextual statement. (Do not allow contradicting non-contextual statements)
A1: for there is not sufficient evidence to suggest that the mean line lengths differ.

Qn	Scheme	Marks	AOs
4(a)	**Shot Ranks** 10 1 8 6 3 5 7 4 1 9 **Goals Rank** 5 6 4 3 2 10 7 9 1 8	B1 B1	1.1b 1.1b
	$\sum d^2 = 128$	B1	1.1b
	$1 - \frac{6 \times 128}{10(10^2 - 1)} = 0.224$	M1 A1	2.1 1.b
		(5)	
(b)	$\mathbf{H_0}: \rho = 0 \quad \mathbf{H_1}: \rho > 0$	B1	2.5
	Critical value at the 5% significance level is 0.5636	B1	1.1b
	0.224 is not significant so do not reject H_0	M1	2.4
	The journalist claim is not supported.	A1	2.2b
		(4)	
(c)	No change in ranks so no change in r_s	B1	2.2a
		(1)	
			(10 marks)

Question 4 notes:

(a) B1: for ranking number of shots on goal
B1: for ranking number of goals scored
B1: for $\sum d^2$
M1: for substituting into $1 - \frac{6 \times \sum d^2}{n(n^2 - 1)}$
A1: awrt 0.224

(b) B1: for both hypotheses correct using correct notation
B1: for critical value = 0.5636
M1: for a correct non-contextual statement. (Do not allow contradicting non-contextual statements)
A1: for the journalist claim is not supported.

(c) B1: for a suitable comment in context.

Qn	Scheme	Marks	AOs
5(a)	$H_0: \mu = 750 \quad H_1: \mu < 750$	B1	2.5
	$[\![s]\!]^2 = 1/5\,(3361537 - [\![4491]\!]^2/6)$] = **4.7**	B1	2.1
	$t = \dfrac{748.5 - 750}{\sqrt{\frac{4.7}{6}}} = -1.6947\ldots$	M1 A1	3.1b 1.1b
	$t_5 = -2.015$	B1	1.1b
	Since $t > -2.015$ we do not reject H_0 and there is no significant evidence that the population mean is less than 750 ml.	A1	2.2b
		(6)	
(b)	Must assume that the amount of juice in a bottle is normally distributed	B1	1.2
		(1)	
			(7 marks)

Question 5 notes:

(a) B1: for both hypotheses correct using correct notation
B1: for 4.7
M1: for use of $\dfrac{\bar{x} - \mu}{\sqrt{\frac{s^2}{n}}}$
A1: for awrt -1.69
B1: for correct t value
A1: for there is no significant evidence that the population mean is less than 750 ml
(b) B1 for a suitable comment mentioning normal distribution

Qn	Scheme	Marks	AOs
6(a)	F($2a$) = 1 so $ka^2 = 1$ $k = \frac{1}{a^2}$	M1 A1	2.1 1.1b
		(2)	
(b)	F(2) = $\frac{1}{4}$ so $\frac{1}{a^2}(2-a)^2 = \frac{1}{4}$	M1	2.1
	$3a^2 - 16a + 16 = 0$ $(3a-4)(a-4) = 0$ so $a = \frac{4}{3}$ * since F(2) = $\frac{1}{4}$ so $a < 2$ (o.e.)	M1 A1 *	1.1b 2.4
		(3)	
(c)	F(m) = $\frac{1}{2}$ so $\frac{9}{16}\left(m-\frac{4}{3}\right)^2 = \frac{1}{2}$	M1	2.1
	Attempt to solve leading to m = … m = awrt 2.28	M1 A1	1.1b 1.1b
		(3)	
(d)	Attempts to differentiate F(x) f(x) = $\frac{9}{8}\left(x-\frac{4}{3}\right)$	M1 A1	2.1 1.1b
	E(X) = $\int_{4/3}^{8/3}\left(\frac{9}{8}x^2 - \frac{3}{2}x\right)dx = \left[\frac{9}{24}x^3 - \frac{3}{4}x^2\right]_{4/3}^{8/3}$	M1 A1	1.1b 1.1b
	= $\frac{16}{9} + \frac{4}{9} = \frac{20}{9}$ *	A1* cso	1.1b
		(5)	
(e)	Mode = $\frac{8}{3}$	B1	1.2
		(1)	

(14 marks)

Question 6 notes:

(a)
M1: for use of F($2a$) = 1
A1: cao

(b)
M1: for use of F(2) = $\frac{1}{4}$
M1: for obtaining a correct quadratic = 0
A1 *: A correct solution with no incorrect working seen and a suitable reason for choice

(c)
M1: for F(m) = $\frac{1}{2}$
M1: for attempting to solve a quadratic leading to m = …
A1: awrt 2.28, must reject other solution outside of range

(d)
M1: for realising the need to differentiate F(x) and x^n going to x^{n-1}
A1ft: for $\frac{9}{8}\left(x-\frac{4}{3}\right)$ k can be follow through for this mark
M1: for integral of x f(x)
A1: for correct integration with limits
A1 *: A correct solution with no incorrect working seen

(e)
B1: for mode = $\frac{8}{3}$

Qn	Scheme	Marks	AOs
7(a)	$X \sim N(20, 0.1^2)$ $Y \sim N(19.7, 0.1^2)$ Require $X - Y$	M1	3.3
	$E(X - Y) = 20 - 19.7 = 0.3$ Var $(X - Y) = 0.1^2 + 0.1^2 = 0.02$	M1 A1 A1	3.4 1.1b 1.1b
	$P(0 < X - Y < 0.15)$ $= 0.12747\ldots$ (calc)	M1 A1	3.4 1.1b
		(6)	
(b)	Let $D = 2Y - X$ $E(D) = 2x19.7 - 20 = 19.4$ $Var(D) = 2^2 \times 0.1^2 + 0.1^2$ $= 0.05$	M1 A1 M1 A1	3.3 1.1b 3.4 1.1b
	$P(D < 19.5)$	M1	2.1
	$= 0.672639\ldots$ (calc)	A1	1.1b
		(6)	
			(12 marks)

Question 7 notes:
(a) M1: for realisation that distribution of $X - Y$ is needed M1: for correct attempt at mean or variance A1: for $E(X - Y) = 0.3$ A1: for Var $(X - Y) = 0.02$ M1: for attempting a correct probability A1: for awrt 0.127
(b) M1: for selecting an appropriate model $D = 2Y - X$ A1: for $E(D) = 19.4$ M1: for a correct method for the variance A1: for $Var(D) = 0.05$ M1: for a correct probability expression (overall strategy mark) A1: for awrt 0.673