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EDEXCEL A LEVEL FURTHER MATHEMATICS: QUESTIONS BY TOPIC

Estimation, Confidence Intervals and Tests Using a Normal Distribution (5)

Further Statistics 2 · Topic 5

9 questions · 103 marks · Mark schemes included

Pearson Edexcel A Level Further Mathematics (9FM0), June 2019 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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4.1 COMBINATIONS OF RANDOM VARIABLES		2 Qs · 22 marks	3
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QUESTIONS

9 questions · 103 marks · 5 sub-topics



SUB-TOPIC 4.1

COMBINATIONS OF RANDOM VARIABLES

Sub-topic 4.1 · 2 questions · 22 marks · lowest tariff first



4. The weights of eggs, E grams, follow a normal distribution, $N(60, 3^2)$

The weights of empty small boxes, S grams, follow a normal distribution, $N(24, 1.8^2)$

The weights of empty large boxes, L grams, follow a normal distribution, $N(40, 2.1^2)$

Small boxes of eggs contain 6 randomly selected eggs.

Large boxes of eggs contain 12 randomly selected eggs.

- (a) Find the probability that the total weight of a randomly selected small box of 6 eggs weighs less than 387 grams.

(3)

- (b) Find the probability that a randomly selected large box of 12 eggs weighs more than twice a randomly selected small box of 6 eggs.

(5)



Question 4 continued

(Total for Question 4 is 8 marks)





Question 7 continued



Question 7 continued



(Total for Question 7 is 14 marks)

SUB-TOPIC 5.1

ESTIMATORS, BIAS AND STANDARD ERROR

Sub-topic 5.1 · 1 question · 11 marks · lowest tariff first



Question 7 continued



Question 7 continued

(Total for Question 7 is 11 marks)



SUB-TOPIC 5.3

CONFIDENCE INTERVALS FOR A NORMAL MEAN

Sub-topic 5.3 · 2 questions · 17 marks · lowest tariff first



Question 1 continued

(Total for Question 1 is 8 marks)



Question 6 continued

(Total for Question 6 is 9 marks)



SUB-TOPIC 5.4

TESTS FOR A DIFFERENCE OF MEANS

Sub-topic 5.4 · 3 questions · 41 marks · lowest tariff first



Question 2 continued



(Total for Question 2 is 9 marks)







Question 6 continued

(Total for Question 6 is 15 marks)



6. Xiang owns a takeaway restaurant and wants to employ a delivery company. Xiang uses two companies, *A* and *B*, for one week each and records the delivery rate, x minutes per km, for each delivery.

Company *A* made 61 deliveries with $\bar{x}_A = 3.7$ and $s_A^2 = 1.64$

Company *B* made 51 deliveries with $\sum x_B = 142.8$ and $\sum x_B^2 = 461.34$

- (a) Find unbiased estimates for the mean and variance of the delivery rate for company *B*.

(3)

Xiang wants to carry out a two-sample t -test to determine whether there is a difference in the mean delivery rate for these companies.

- (b) State any assumptions Xiang must make about the delivery rates of the two companies.

(1)

- (c) Using a 5% level of significance, carry out Xiang's test. You should clearly state the hypotheses, test statistic and critical value you use.

(7)

Xiang noticed that a greater proportion of company *A*'s deliveries were in the town, with lots of traffic, whereas a greater proportion of company *B*'s deliveries were rural, with less traffic.

Xiang decides to carry out a further test. He selects a random sample of 10 customers who regularly place an order at the same time each week. He asks company *A* to deliver these orders one week and company *B* the next week. There were no roadworks or other incidents affecting travel time in either week.

The delivery rates are given in the table below.

Customer	1	2	3	4	5	6	7	8	9	10
Company <i>A</i>	5.4	3.6	2.5	4.7	2.3	3.2	3.4	4.1	5.9	4.5
Company <i>B</i>	4.9	3.9	2.3	4.5	2.6	2.8	3.1	3.8	5.2	4.3

- (d) Use a 5% level of significance to carry out a suitable test to determine whether there is a difference in the delivery rates of the two companies.
You should clearly state your hypotheses, test statistic and critical value.

(6)

Question 6 continued



Question 6 continued

Question 6 continued

(Total for Question 6 is 17 marks)



SUB-TOPIC 7.1

T-TESTS AND CONFIDENCE INTERVALS FOR A MEAN

Sub-topic 7.1 · 1 question · 12 marks · lowest tariff first



- 6** A new employee, Kim, joins an existing employee, Jiang, to work in the quality control department of a company producing steel rods. Each day a random sample of rods is taken, their lengths measured and a 95% confidence interval for the mean length of the rods, in metres, is calculated. It is assumed that the lengths of the rods produced are normally distributed.
- Kim took a random sample of 25 rods and used the t distribution to obtain a 95% confidence interval of (1.193, 1.367) for the mean length of the rods. Jiang commented that this interval was a little wider than usual and explained that they usually assume that the standard deviation does not change and can be taken as 0.175 metres.
- (a) Test, at the 10% level of significance, whether or not Kim's sample suggests that the standard deviation is different from 0.175 metres. State your hypotheses clearly.

Using Kim's sample and the normal distribution with a standard deviation of 0.175 metres,

- (b) find a 95% confidence interval for the mean length of the rods.

Question 6 continued

(Total for Question 6 is 12 marks)



MARK SCHEMES

official mark schemes



Question	Scheme	Marks	AOs
4(a)	$W = E_1 + E_2 + \dots + E_6 + S \sim N(6 \times 60 + 24, 6 \times 3^2 + 1.8^2)$ [$W \sim N(384, 57.24)$]	M1M1	3.3 1.1b
	$P(W < 387) = 0.6541\dots$ awrt <u>0.654</u>	A1	3.4
		(3)	
(b)	$X = E_1 + E_2 + \dots + E_{12} + L \sim N(12 \times 60 + 40, 12 \times 3^2 + 2.1^2)$ [$X \sim N(760, 112.41)$]	M1	1.1b
	$2W \sim N(384 \times 2, 57.24 \times 2) = N(768, 228.96)$	M1	1.1b
	$X - 2W \sim N(760 - 768, 112.41 + 228.96) \rightarrow N(-8, 341.37)$	M1A1	3.3 1.1b
	$P(X - 2W > 0) = 0.3325\dots$ awrt <u>0.333</u>	A1	3.4
		(5)	
(8 marks)			
Notes			
(a)	M1: setting up normal model with correct mean M1: use of correct variance A1: awrt 0.654		
(b)	M1: setting up normal model for large box of eggs, sight of $12 \times 60 + 40$ M1: sight or use of 2 times their mean from (a) and 4 times their variance from (a) M1: setting up distribution for the difference in weights, with mean of their “760” – “768” A1: correct mean and variance A1: awrt 0.333		

Question	Scheme	Marks	AOs
7(a)	$(A + R) \sim N(300, 12^2 + 10^2)$	M1	3.3
	$(A_1 + A_2) \sim N(320, 2 \times 12^2)$	A1	1.1b
		A1	1.1b
		(3)	
(b)	$P(\text{both are apples}) [= \frac{4}{5} \times \frac{3}{4}] = \frac{3}{5}$	M1	2.1
	$P(\text{one apple and one orange}) = \frac{2}{5}$		
	$\frac{3}{5} P(A_1 + A_2 > 310) + \frac{2}{5} P(A + R > 310)$	M1	2.1
	$= 0.5377 \dots$ awrt 0.538	A1	1.1b
		(3)	
(c)	$[W = \sum_1^m A - n \times R]$		
	$W \sim N(160m - 140n, m \times 12^2 + n^2 \times 10^2)$	M1	3.3
		A1	1.1b
	$160m - 140n = (1100.08 + 1499.92) \div 2 [= 1300]$	M1	2.1
	$2 \times 1.96 \times \sqrt{m \times 12^2 + n^2 \times 10^2} = (1499.92 - 1100.08)$	B1	1.1b
	$[\sqrt{m \times 12^2 + n^2 \times 10^2} = 102]$	M1	1.1b
	$m = \frac{1300 + 140n}{160} \rightarrow \sqrt{(\frac{1300 + 140n}{160}) \times 12^2 + n^2 \times 10^2} = 102$	dM1	2.1
	$100n^2 + 126n - 9234 = 0$		
	$n = 9$ ($n = -10.26$ reject)	A1	1.1b
	$m = 16$	A1	1.1b
		(8)	
(14 marks)			
Notes			
(a)	M1: Setting up either model for the weights of the two fruit A1: Correct distribution for 1 apple 1 orange A1: Correct distribution for 2 apples		
(b)	M1: Finding probability for each possible outcome M1: Fully correct method for finding the required probability A1: awrt 0.538		
(c)	M1: Setting up model for W A1: correct distribution M1: Using given interval to set up equation for mean B1: 1.96 M1: Using given interval to set up equation for variance dM1: Solving simultaneously leading to a 3TQ (dep on previous M mark) A1: $n = 9$ (only) A1: $m = 16$ (only)		

Qu	Scheme	Mark	AO
7 (a)	[Let $D = \bar{X} - Y$] $E(D) = 0$	B1	1.1b
	$(D =) \frac{X_1 + X_2 + X_3 + X_4 + X_5}{5} - \frac{X_1 + X_5}{2}$ oe	M1	3.1a
	$= \frac{1}{10} [2(X_2 + X_3 + X_4) - 3(X_1 + X_5)]$ oe	M1 A1	2.1 1.1b
	$\text{Var}(D) = = \frac{1}{100} (4 \times 3\sigma^2 + 9 \times 2\sigma^2)$	dM1	1.1b
	$= \frac{3}{10} \sigma^2$	A1	1.1b
	So $P(D > \sigma) = P\left(Z > \frac{\sigma - 0}{\sigma\sqrt{\frac{3}{10}}}\right) = 0.03394\dots$ awrt 0.034	A1	3.2a
		(7)	
(b)	(27.029, 37.371) since this is the narrower interval or her sample was greater oe	B1	2.2a
		(1)	
(c)	e.g. $37.371 - 27.029 = [2] \times \frac{\sigma}{\sqrt{5}} \times 1.96$ (or $38.177 - 21.823 = [2] \times \frac{\sigma}{\sqrt{2}} \times 1.96$)	M1	3.4
	$\sigma = \frac{10.342 \times \sqrt{5}}{2 \times 1.96}$	A1	1.1b
	$= 5.8993\dots$ awrt 5.9	A1	1.1b
	$\sigma = \frac{16.354 \times \sqrt{2}}{2 \times 1.96}$ $= 5.900\dots$ awrt 5.9		
		(3)	
	(11 marks)		
	Notes		
(a)	B1 for $E(D) = 0$ (May be implied by their other working). May use other letters. 1 st M1 for an attempt at $\bar{X} - Y$ (any expression using X_1, X_2, X_3, X_4 and X_5). May be seen in attempt to find a probability or $E(D)$ 2 nd M1 for an attempt to eliminate the “repeats” – condone missing $\frac{1}{10}$ or errors in “2” and “3” 1 st A1 for a correct expression for D with no “repeats” 3 rd dM1 for a correct application of $\text{Var}(aX - bY)$ dep on 2nd M1 but can fit their expression 2 nd A1 for the correct variance (may be implied by a correct answer) 3 rd A1 for awrt 0.034		
(b)	B1 for choosing the correct interval and giving a suitable reason based on width or sample size. Contradictory or incorrect statements is B0. Do not accept just referring to the standard deviation being smaller without going onto explain the effect on the width of the interval		
(c)	M1 for an attempt at a correct equation in σ . Condone wrong n and missing $\times 2$ must have 1.96. Alternatively for an attempt to form two simultaneous equations in $\bar{x}$ and σ , condoning a wrong n . (Condone labelling $\bar{x}$ as μ) Must have 1.96 1 st A1 for a correct expression for σ . May be implied by awrt 5.9 2 nd A1 for awrt 5.9		



1(a)		Mean = 504	B1	1.1b
		1.96	B1	3.3
		$504 \pm \frac{5.4}{\sqrt{8}} \times "1.96"$	M1	2.1
		(500.258, 507.742)	A1	1.1b
			(4)	
(b)		505 is in the confidence interval therefore there is evidence that the machine is working properly	B1ft	2.2b
			(1)	
(c)		5% oe	B1	1.1b
			(1)	
(d)		s needs to be used instead of σ and a t-value instead of the z value	B1	3.3
		since the sample is small therefore you can't use the normal distribution	B1	3.5b
			(2)	
(8 marks)				
Notes:				
(a)	B1	504 may be seen in part(b)		
	B1	For realising a normal distribution must be used as a model and finding the correct value 1.96		
	M1	For $504 \pm \frac{5.4}{\sqrt{8}} \times "z \text{ value}"$. $ z > 1$ May be implied by a correct CI		
	A1	awrt 500.26 and 507.74 NB using t gives 500.29 and 507.71		
(b)	B1ft	Drawing a correct inference (ft) using their answer to part (a) and the 505 from the question. Reason must be given. Ignore incorrect non – contextual		
(c)	B1	5%		
(d)	B1	create new model by using s and t. Allow if state use CI $\mu \pm \frac{s}{\sqrt{n}} \times "t"$ or use s = 4.44 and t = 2.365		
	B1	For recognising that the sample is small		

Question	Scheme	Marks	AOs
6	99% confidence interval for Var uses χ^2 values of 1.735 or 23.589	B1	3.3
	$\frac{9s^2}{1.735} = 0.2328$ or $\frac{9s^2}{23.589} = 0.01712$	M1	2.1
	$s^2 = \frac{0.2328 \times "1.735"}{9}$ or $\frac{0.01712 \times "23.589"}{9}$ [= 0.04487...]	dM1	1.1b
	$\bar{x} = 4.84$	B1	1.1b
	$H_0: \mu = 5$ $H_1: \mu < 5$	B1	2.5
	CV $t_9 = -1.833$	B1	1.1b
	$t = \pm \frac{"4.84" - 5}{\sqrt{"0.0449"/10}}$	M1	1.1b
	= awrt -2.39	A1	1.1b
	Stan's belief is supported or there is evidence that the mean diameter of the bolts is less than 5mm	A1ft	2.2b
		(9)	
(9 marks)			
Notes:			
B1: For realising a χ^2 distribution must be used as a model and finding a correct value			
M1: For realising the need to set $\frac{9s^2}{\text{"smallest } \chi^2"} = 0.2328$ or $\frac{9s^2}{\text{"largest } \chi^2"} = 0.01712$			
dM1: correct method used to solve equation to find s^2			
B1: awrt 4.84			
B1: Both hypotheses correct using the notation μ			
B1: ± 1.833			
M1: For us of correct formula ie $\pm \frac{"their 4.84" - 5}{\sqrt{"their 0.0449"/10}}$ If "4.84" not shown it must be correct here			
A1: -2.39			
A1ft: Drawing a correct inference following through their CV and test statistic (must have matching signs)			
NB if chi squared values not shown $s^2 = 0.045$ or 0.0449 award B0 M1M1 for awrt 0.04487 award B1 M1 A1			
Use of $2(2.5758) \frac{\sigma}{\sqrt{10}} = 0.21568$ gives $\sigma = \sqrt{0.0175}$ could get B0M0M0B1B1B1M0A0A0			
Unless continue to get $s^2 = \frac{10}{9} 0.0175 = 0.0194...$			
Use of $2(1.833) \frac{s}{\sqrt{10}} = 0.21568$ gives $s = 0.1860$ could get B0M0M0B1B1B1M1A0A1			

Question	Scheme	Marks	AOs
2(a)	$H_0: \mu_{b(lue)} = \mu_{w(hite)} + 5$ $H_1: \mu_{b(lue)} > \mu_{w(hite)} + 5$	B1	2.1
	$s.e. = \sqrt{\frac{2.6^2}{90} + \frac{2.4^2}{80}}$	M1	1.1b
	$z = \frac{39.5 - 33.7 - 5}{\sqrt{\frac{2.6^2}{90} + \frac{2.4^2}{80}}} = 2.085773...$ awrt 2.09	M1 A1	3.1b 1.1b
	CV = 2.3263 [or p -value = 0.01849...]	B1	1.1b
	Not significant, insufficient evidence to support Nissim's claim.	A1	2.2b
		(6)	
(b)	Use the t - test or (Since sample sizes are large,) use s^2 as an approximation to σ^2	B1	2.4
		(1)	
(c)	Since sample size is large, by the Central Limit Theorem, sample means will be (approximately) normally distributed ...so no effect as the calculations in part (a) can still be carried out.	B1	2.4
		dB1	3.2b
		(2)	
(9 marks)			
Notes			
(a)	B1: Both hypotheses (oe) correct with correct notation (if using μ_x and μ_y these must be defined). M1: Calculation of standard error M1: Standardising using normal distribution test statistic for difference of two means with known variance A1: awrt 2.09 B1: Correct critical value 2.3263 or better A1: Drawing a correct inference in context		
(b)	B1: Correct explanation		
(c)	B1: Understanding that the assumptions required for the hypothesis test, by CLT sample means follow a normal distribution dB1: (dep on previous B1) Correct evaluation		

Question	Scheme	Marks	AOs
6(a)	$H_0: \sigma_r^2 = \sigma_{mb}^2 \quad H_1: \sigma_r^2 \neq \sigma_{mb}^2$	B1	2.5
	$s_r^2 = \frac{1}{7} \left(21032 - 8 \times \left(\frac{410}{8} \right)^2 \right) = 2.7857...$	M1 A1	2.1 1.1b
	$s_{mb}^2 = \frac{1}{5} \left(14426 - 6 \times \left(\frac{294}{6} \right)^2 \right) = 4$	A1	1.1b
	$\frac{s_{mb}^2}{s_r^2} = 1.4358...$	M1	3.4
	CV $F_{5,7} = 7.46$	B1	1.1b
	$(1.4358... < 7.46$ so there is) insufficient evidence to suggest the variances of the wingspans are different.	A1	2.2b
		(7)	
(b)	$\chi_{5,\alpha}^2 = \frac{5 \times '4'}{1.194} \quad \text{or} \quad \chi_{5,\alpha}^2 = \frac{5 \times '4'}{48.54}$	M1	3.1b
	$\chi_{5,\alpha}^2 = 16.75 \rightarrow \alpha = 0.005 \quad \text{or} \quad \chi_{5,\alpha}^2 = 0.412 \rightarrow \alpha = 0.995$	M1	1.1b
	$k = 99$	A1	1.1b
		(3)	
(c)	$s_p^2 = \frac{7 \times '2.7857...' + 5 \times '4'}{8 + 6 - 2} [= 3.29...]$	M1	3.1b
	$t_{12} = 2.179$	B1	1.1b
	$\left(\frac{410}{8} - \frac{294}{6} \right) \pm '2.179' \times \sqrt{'3.29'} \sqrt{\frac{1}{8} + \frac{1}{6}}$	M1	3.4
	(awrt 0.115, awrt 4.39)	A1 A1	1.1b 1.1b
		(5)	
(15 marks)			
Notes			
(a)	B1: For both hypotheses in terms of σ M1: Correct method for s_r^2 or s_{mb}^2 A1: awrt 2.79 (allow $\frac{39}{14}$) A1: 4 cao M1: Using correct model for test statistic with correct ratio B1: Correct CV A1ft: Drawing a correct inference in context using their CV and their test statistic (dep on both M marks)		
(b)	M1: Either correct attempt at $\chi_{5,\alpha}^2$ with $\nu = 5$ M1: Using tables to find appropriate probability A1: 99 cao		
(c)	M1: Correct expression for s_p^2 B1: Correct 95% t -value M1: CI in the correct form (may be implied by either A mark) A1: awrt 0.115 A1: awrt 4.39		
Question	Scheme	Marks	AOs

Qu	Scheme	Mark	AO
6(a)	$\bar{x}_B = 2.8$ oe	B1	1.1b
	$s_B^2 = \frac{461.34 - 51 \times 2.8^2}{50} ; = \underline{1.23}$ oe	M1;A1	1.1b;1.1b
		(3)	
(b)	Delivery rates must be <u>normally</u> distributed with <u>equal variances</u>	B1	2.4
		(1)	
(c)	$H_0 : \mu_A = \mu_B \quad H_1 : \mu_A \neq \mu_B$ oe	B1	2.5
	$s_p^2 = \frac{1.64 \times 60 + "1.23" \times 50}{110} ; = 1.4536... \quad \text{awrt } \underline{1.45}$	M1;A1	1.1b;1.1b
	$t_{110} = \pm \frac{3.7 - "2.8"}{\sqrt{"1.45..."(\frac{1}{61} + \frac{1}{51})}} = 3.93419... \quad \text{awrt } \underline{3.93 \text{ or } 3.94}$	M1;A1	3.4;1.1b
	5% 2-tail cv = ± 1.982	B1	1.1b
	[significant result] there is evidence of a difference in <u>mean delivery rates</u> oe	A1	2.2b
(d)		(7)	
	[Let $D = \text{delivery A} - \text{delivery B}$] $H_0 : \mu_D = 0 \quad H_1 : \mu_D \neq 0$	B1	2.5
	$d = 0.5, -0.3, 0.2, 0.2, -0.3, 0.4, 0.3, 0.3, 0.7, 0.2$ (may be opposite signs)	M1	2.1
	$[\bar{x}_D = 0.22 \quad s_D = 0.31552...] \quad t_{[9]} = \pm \frac{"0.22" - 0}{\frac{"0.31552..."}{\sqrt{10}}} = 2.2049...; \text{awrt } \underline{2.20}$	M1;A1	3.4;1.1b
	Two-tail $t_9(5\%)$ cv = ± 2.262	B1	1.1b
(d)	[Not significant] <u>insufficient</u> evidence of a difference in <u>delivery rates</u> oe	A1	2.2b
		(6)	
(17 marks)			
Notes			
(a)	B1 for 2.8 (may be seen in a calculation but must be seen somewhere) oe M1 for a correct expression for s^2 Can fit their mean or implied by correct answer. A1 for 1.23 oe		
(b)	B1 for mention of “normal” and “equal variance” (or standard deviation)		
(c)	1 st B1 for correct hypotheses, both in terms of μ . Can be μ_1 and μ_2 etc 1 st M1 for correct attempt at s_p^2 ft their value for B ; 1 st A1 for awrt 1.45 (implied by 2 nd A1) ($\frac{1599}{1100}$) 2 nd M1 for correct ft expression for test statistic using 3.7 allow ($\pm$) standardisation ; 2 nd A1 for awrt ($\pm$) 3.93 or awrt ($\pm$) 3.94 2 nd B1 for ($\pm$)1.982 (or better) 3 rd A1 dep on all previous Ms and $1 < cv < "3.93"$ for correct conclusion mentioning “mean delivery rate” . Do not allow contradictory statements. Incorrect comparisons A0.		
(d)	1 st B1 for both hypotheses in terms of μ (or μ_d) but not μ_1 and μ_2 etc 1 st M1 for attempting differences (at least 6 correct values) implied by mean or s_D^2 or s_D 2 nd M for a correct express’n for t (ignore df) with their values for $\bar{x}_D$ and s_D (correct method) 1 st A1 for awrt ± 2.20 or ± 2.205 (accept 2.2 if correct expression or $\bar{x}_D$ and s_D seen) 2 nd B1 for correct cv i.e. ± 2.262 or better 2 nd A1 dep on all previous Ms and “2.20” $< cv < 3$ for correct conclusion in context. Do not allow contradictory statements. “mean delivery rate” or incorrect comparison is A0. SC If they carry out a t-test for two independent samples then allow 2nd M1 for standardising with diff of their means and pooled variance and 2nd B1 for cv of ± 2.101		

Qu	Scheme	Marks	AO
6(a)	From CI $\bar{x} = \frac{1.193+1.367}{2} = 1.28$	B1	1.1b
	or width = $1.367 - 1.193 = 0.174$		
	$1.367 = "1.28" \pm 2.064 \times \frac{s}{\sqrt{25}}$ or " 0.174 " = $2 \times 2.064 \times \frac{s}{\sqrt{25}}$	M1;A1	3.4 1.1b
	$\Rightarrow s = 0.210755...$	A1	1.1b
	$H_0 : \sigma = 0.175$ $H_1 : \sigma \neq 0.175$	B1	2.5
	$\chi_{24}^2 = \frac{24s^2}{\sigma^2} =$ $34.8092...$ awrt 34.8	M1, A1	3.3 1.1b
	$\chi_{24}^2 (10\%)$ 2-tail CR is $\chi_{24}^2 < \underline{13.848}$ or $\chi_{24}^2 > \underline{36.415}$	B1	2.1
	34.8 is not significant so insufficient evidence that $\sigma \neq 0.175$	A1	2.2b
		(9)	
	(b) " 1.28 " $\pm z \times \frac{0.175}{\sqrt{25}}$	M1	3.3
	$= (1.211..., 1.349...) =$ awrt <u>(1.21, 1.35)</u>	z = 1.96 B1 A1	1.1b 1.1b
		(3)	
		(12 marks)	
Notes			
(a)	1 st B1 for finding mean from CI or calculation of width of CI 1 st M1 for using the given t model to form an equation in s . (Allow t for 2.064 where $2 < t < 3$) 1 st A1 for correct use of $t_{24} = 2.064$ 2 nd A1 for $s = 0.21$ or better 2 nd B1 for correct hypotheses in terms of σ . 2 nd M1 for selecting the appropriate model for this test 3 rd A1 for test statistic awrt 34.8 3 rd B1 for at least one correct critical value 4 th A1 for a correct conclusion confirming that assuming st. dev = 0.175 is OK		
(b)	M1 for use of correct formula with $1.6 < z < 2$ (ft $\bar{x}$ if found in (a)) B1 for $z = 1.96$ or better used A1 for an interval awrt (1.21, 1.35)		

Qu	Scheme	Marks	AO
7(a)	$X = L_1 + L_2 + L_3 \sim N\left(594, \sqrt{75}^2\right)$	M1	3.3
		A1	1.1b
	$Y = S_1 + \dots + S_8 \sim N\left(592, \sqrt{72}^2\right)$	A1	1.1b
	$P(X > Y) = P(D > 0)$ where $D \sim N\left(2, \sqrt{147}^2\right)$	M1	2.1
		A1ft	1.1b
	$= 0.56551\dots$ awrt 0.566	A1	3.4
		(6)	
	(b) $W = L - \frac{8}{3}S \Rightarrow W \sim N\left(\frac{2}{3}, 25 + \frac{64}{9} \times 9\right) = N\left(\frac{2}{3}, \sqrt{89}^2\right)$	M1	3.3
		M1,A1	2.1,1.1b
	$P(W > 0) = 0.528168\dots$ awrt 0.528	M1A1	3.4,1.1b
		(5)	
	(c) $F = L_1 + \dots + L_5 \sim N\left(990, \sqrt{125}^2\right)$	M1	3.1b
		A1	1.1b
	$P(F < 1000) = 0.814455\dots$ (o.e.)	A1	3.4
	E(cost of Rosa's plan) = $430 \times "0.814\dots" + 400 \times (1 - "0.814\dots")$	M1	2.1
	$= \text{£ } 424.43$	A1	1.1b
	Buying 14 small panels cost $14 \times 30 = \text{£}420$	A1	3.2a
	So Rosa's plan is likely to be <u>more expensive</u>	(6)	
		(17 marks)	
Notes			
(a)	1 st M1 for an attempt at X or Y – expression or implied by one correct distribution		
	1 st A1 for a correct distribution for X <u>or</u> implied by $E(D) = 2$		
	2 nd A1 for a correct distribution for Y <u>or</u> implied by $\text{Var}(D) = 147$		
	2 nd M1 for a correct strategy – attempt $X - Y$ and $P(D > 0)$ statement		
	3 rd A1ft for a correct distribution for D ft their X and Y		
	4 th A1 for awrt 0.566		
(b)	1 st M1 for attempt at a correct model (normal and mean)		
	2 nd M1 for correct expression for variance of their model provided of the form $L - kS$ <u>or</u> $kL - S$		
	1 st A1 for a fully correct distribution		
	3 rd M1 for a correct probability statement using their distribution		
	2 nd A1 for awrt 0.528		
(c)	1 st M1 for a correct start to solve the problem attempt at F and correct mean		
	1 st A1 for a correct distribution		
	2 nd A1 for using this model to find $P(F < 1000) = \text{awrt } 0.814$ or $P(F > 1000) = \text{awrt } 0.186$		
	2 nd M1 for a correct strategy to solve the problem i.e. attempt at expected cost ft their prob		
	3 rd A1 for awrt £424		
	4 th A1 for a correct conclusion must have comparison with £420 and reject Rosa's plan		
[(c) is an extended problem and a 3.1, 3.2 question]			