1. A teacher wishes to test whether playing background music enables students to complete a task more quickly. The same task was completed by 15 students, divided at random into two groups. The first group had background music playing during the task and the second group had no background music playing.
The times taken, in minutes, to complete the task are summarised below.

	Sample size n	Standard deviation s	Mean $\bar{x}$
With background music	8	4.1	15.9
Without background music	7	5.2	17.9

You may assume that the times taken to complete the task by the students are two independent random samples from normal distributions.

(a) Stating your hypotheses clearly, test, at the 10% level of significance, whether or not the variances of the times taken to complete the task with and without background music are equal.

(5)

(b) Find a 99% confidence interval for the difference in the mean times taken to complete the task with and without background music.

(7)

Experiments like this are often performed using the same people in each group.

(c) Explain why this would not be appropriate in this case.

(1)
(Total 13 marks)

2. A car manufacturer claims that, on a motorway, the mean number of miles per gallon for the Panther car is more than 70. To test this claim a car magazine measures the number of miles per gallon, x, of each of a random sample of 20 Panther cars and obtained the following statistics.

$$\bar{x} = 71.2 \qquad s = 3.4$$

The number of miles per gallon may be assumed to be normally distributed.

(a) Stating your hypotheses clearly and using a 5% level of significance, test the manufacturer's claim.

(5)

The standard deviation of the number of miles per gallon for the Tiger car is 4.

(b) Stating your hypotheses clearly, test, at the 5% level of significance, whether or not there is evidence that the variance of the number of miles per gallon for the Panther car is different from that of the Tiger car.

(6)
(Total 11 marks)

3. A farmer set up a trial to assess whether adding water to dry feed increases the milk yield of his cows. He randomly selected 22 cows. Thirteen of the cows were given dry feed and the other 9 cows were given the feed with water added. The milk yields, in litres per day, were recorded with the following results.

	Sample size	Mean	s^2
Dry feed	13	25.54	2.45
Feed with water added	9	27.94	1.02

You may assume that the milk yield from cows given the dry feed and the milk yield from cows given the feed with water added are from independent normal distributions.

(a) Test, at the 10% level of significance, whether or not the variances of the populations from which the samples are drawn are the same. State your hypotheses clearly.

(5)

(b) Calculate a 95% confidence interval for the difference between the two mean milk yields.

(7)

(c) Explain the importance of the test in part (a) to the calculation in part (b).

(2)
(Total 14 marks)

4. A large number of students are split into two groups *A* and *B*. The students sit the same test but under different conditions. Group A has music playing in the room during the test, and group B has no music playing during the test. Small samples are then taken from each group and their marks recorded. The marks are normally distributed.

The marks are as follows:

Sample from Group *A*	42	40	35	37	34	43	42	44	49
Sample from Group *B*	40	44	38	47	38	37	33		

(a) Stating your hypotheses clearly, and using a 10% level of significance, test whether or not there is evidence of a difference between the variances of the marks of the two groups.
(8)

(b) State clearly an assumption you have made to enable you to carry out the test in part (a).
(1)

(c) Use a two tailed test, with a 5% level of significance, to determine if the playing of music during the test has made any difference in the mean marks of the two groups. State your hypotheses clearly.
(7)

(d) Write down what you can conclude about the effect of music on a student's performance during the test.
(1)
(Total 17 marks)

5. The lengths, x mm, of the forewings of a random sample of male and female adult butterflies are measured. The following statistics are obtained from the data.

	No. of butterflies	Sample mean $\bar{x}$	$\sum x^2$
Females	7	50.6	17 956.5
Males	10	53.2	28 335.1

(a) Assuming the lengths of the forewings are normally distributed test, at the 10% level of significance, whether or not the variances of the two distributions are the same. State your hypotheses clearly.

(7)

(b) Stating your hypotheses clearly test, at the 5% level of significance, whether the mean length of the forewings of the female butterflies is less than the mean length of the forewings of the male butterflies.

(6)
(Total 13 marks)

6. The weights, in grams, of apples are assumed to follow a normal distribution. The weights of apples sold by a supermarket have variance σ_S^2. A random sample of 4 apples from the supermarket had weights

114, 110, 119, 123.

(a) Find a 95% confidence interval for σ_S^2.

(7)

The weights of apples sold on a market stall have variance $\sigma_M^{2.}$ A second random sample of 7 apples was taken from the market stall. The sample variance s_M^2 of the apples was 318.8.

(b) Stating your hypotheses clearly test, at the 1% level of significance, whether or not there is evidence that $\sigma_M^2 > \sigma_S^2$.

(5)
(Total 12 marks)

7. Two machines *A* and *B* produce the same type of component in a factory. The factory manager wishes to know whether the lengths, *x* cm, of the components produced by the two machines have the same mean. The manager took a random sample of components from each machine and the results are summarised in the table below.

	Sample Size	Mean $\bar{x}$	Standard Deviation *s*
Machine *A*	9	4.83	0.721
Machine *B*	10	4.85	0.572

The lengths of components produced by the machines can be assumed to follow normal distributions.

(a) Use a two tail test to show, at the 10% significance level, that the variances of the lengths of components produced by each machine can be assumed to be equal.

(4)

(b) Showing your working clearly, find a 95% confidence interval for $\mu_B - \mu_A$, where μ_A and μ_B are the mean lengths of the populations of components produced by machine *A* and machine *B* respectively.

(7)

There are serious consequences for the production at the factory if the difference in mean lengths of the components produced by the two machines is more than 0.7 cm.

(c) State, giving your reason, whether or not the factory manager should be concerned.

(2)
(Total 13 marks)

8. A psychologist gives a test to students from two different schools, *A* and *B*.
A group of 9 students is randomly selected from school *A* and given instructions on how to do the test.

A group of 7 students is randomly selected from school *B* and given the test without the instructions.

The table shows the time taken, to the nearest second, to complete the test by the two groups.

A	11	12	12	13	14	15	16	17	17
B	8	10	11	13	13	14	14		

Stating your hypotheses clearly,

(a) test at the 10% significance level, whether or not the variance of the times taken to complete the test by students from school *A* is the same as the variance of the times taken to complete the test by students from school *B*. (You may assume that times taken for each school are normally distributed.)

(7)

(b) test at the 5% significance level, whether or not the mean time taken to complete the test by students from school *A* is greater than the mean time taken to complete the test by students from school *B*.

(7)

(c) Why does the result to part (a) enable you to carry out the test in part (b)?

(1)

(d) Give one factor that has not been taken into account in your analysis.

(1)
(Total 16 marks)

9. The random variable X has a χ^2-distribution with 9 degrees of freedom.

(a) Find P($2.088 < X < 19.023$).

(3)

The random variable Y follows an F-distribution with 12 and 5 degrees of freedom.

(b) Find the lower and upper 5% critical values for Y.

(3)
(Total 6 marks)

10. The standard deviation of the length of a random sample of 8 fence posts produced by a timber yard was 8 mm. A second timber yard produced a random sample of 13 fence posts with a standard deviation of 14 mm.

(a) Test, at the 10% significance level, whether or not there is evidence that the lengths of fence posts produced by these timber yards differ in variability. State your hypotheses clearly.

(5)

(b) State an assumption you have made in order to carry out the test in part (a).

(1)
(Total 6 marks)

11. A mechanic is required to change car tyres. An inspector timed a random sample of 20 tyre changes and calculated the unbiased estimate of the population variance to be 6.25 minutes^2. Test, at the 5% significance level, whether or not the standard deviation of the population of times taken by the mechanic is greater than 2 minutes. State your hypotheses clearly.

(Total 6 marks)

12. A grocer receives deliveries of cauliflowers from two different growers, *A* and *B*. The grocer takes random samples of cauliflowers from those supplied by each grower. He measures the weight x, in grams, of each cauliflower. The results are summarised in the table below.

	Sample size	$\sum x$	$\sum x^2$
A	11	6600	3960540
B	13	9815	7410579

(a) Show, at the 10% significance level, that the variances of the populations from which the samples are drawn can be assumed to be equal by testing the hypothesis $H_0: \sigma_A^2 = \sigma_B^2$ against hypothesis $H_1: \sigma_A^2 \neq \sigma_B^2$.

(You may assume that the two samples come from normal populations.)

(6)

The grocer believes that the mean weight of cauliflowers provided by *B* is at least 150 g more than the mean weight of cauliflowers provided by *A*.

(b) Use a 5% significance level to test the grocer's belief.

(8)

(c) Justify your choice of test.

(2)
(Total 16 marks)

13. A beach is divided into two areas *A* and *B*. A random sample of pebbles is taken from each of the two areas and the length of each pebble is measured. A sample of size 26 is taken from area *A* and the unbiased estimate for the population variance is s_A^2 = 0.495 mm^2. A sample of size 25 is taken from area *B* and the unbiased estimate for the population variance is s_B^2 = 1.04 mm^2.

(a) Stating your hypotheses clearly test, at the 10% significance level, whether or not there is a difference in variability of pebble length between area *A* and area *B*.

(5)

(b) State the assumption you have made about the populations of pebble lengths in order to carry out the test.

(1)
(Total 6 marks)

1.	(a)	$\mathrm{H}_0 : \sigma_1^2 = \sigma_2^2,\ \mathrm{H}_1 : \sigma_1^2 \neq \sigma_2^2$	B1	
		critical values $\mathrm{F}_{6,7} = 3.87 \left(\frac{1}{\mathrm{F}_{6,7}} = 0.258 \right)$	B1	
		$\frac{s_2^2}{s_1^2} = \frac{5.2^2}{4.1^2}; = 1.61 \quad \left(\frac{s_1^2}{s_2^2} = \frac{4.1^2}{5.2^2} = 0.622 \right)$	M1; A1	
		Since 1.61 (0.622) is not in the critical region we accept H_0 and conclude there is no evidence that the two variances are different	A1ft	5
	(b)	$Sp^2 = \frac{7 \times 4.1^2 + 6 \times 5.2^2}{7 + 6}$ = 21.53…	M1 A1	
		t_{13}=3.012	B1	
		99% CI = (17.9 – 15.9) $\pm$ 3.012 $\times \sqrt{21.53} \times \sqrt{\frac{1}{8} + \frac{1}{7}}$	M1 A1ft	
		= $\pm$ (9.23, –5.233), [or accept: [0,9.23] or [–9.23,0]] awrt 9.23, –5.23	A1 A1	7
	(c)	a person will be quicker at the task second time through/ times not independent/ familiar with the task/groups are not independent	B1	1

Note

B1 Allow $\sigma_1 = \sigma_2$ and $\sigma_1 \neq \sigma_2$
B1 must match their F
M1 for $\frac{s_2^2}{s_1^2}$ or other way up
A1 awrt 1.61(0.622)
M1 A1 Sp^2 may be seen in part a
B1 3.012 only

M1 for (17.9 – 15.9) ± t value $\times \sqrt{S_p{}^2} \times \sqrt{\frac{1}{8}+\frac{1}{7}}$
A1ft their Sp^2
A1 awrt 9.23/–9.23 A1 awrt –5.23/5.23
(c) B1 any correct sensible comment

[13]

2. (a) H_0: $\mu = 70$ [accept ≤ 70], H_1: $\mu > 70$ — B1

$t = \frac{71.2 - 70}{3.4/\sqrt{20}} = 1.58$ — M1 A1

critical value $t_{19}(5\%) = 1.729$ — B1

not significant, insufficient evidence to confirm manufacturer's claim — A1 ft — 5

Note

B1 both hypotheses using μ
M1 $\frac{71.2 - 70}{3.4/\sqrt{20}}$
A1 awrt 1.73
A1 correct conclusion ft their t value and CV

(b) H_0: $\sigma^2 = 16$, H_1: $\sigma^2 \neq 16$ B1

test statistic $\frac{(n-1)s^2}{\sigma^2}$ =, $\frac{219.64}{16}$ = 13.7.. M1 A1

critical values $\chi^2_{19}\,(5\%)\,\text{upper tail} = 32.852$, $\chi^2_{19}\,(5\%)\,\text{lower tail} = 8.907$ not significant B1 B1

Insufficient evidence to suggest that the variance of the miles per gallon of the panther is different from that of the Tiger. A1ft 6

Note

B1 both hypotheses and 16. accept σ = 4 and σ ≠ 4

M1 $\frac{(19)\times 3.4^2}{16}$ allow $\frac{(19)\times 3.4^2}{4}$

A1 awrt 13.7

B1 32.852

B1 8.907

A1 correct contextual comment

NB those who use σ^2 = 4 throughout can get B0 M1 A0B1 B1 A1

[11]

3. (a) H_0: $\sigma_A^2 = \sigma_B^2, H_1: \sigma_A^2 \neq \sigma_B^2$ B1

critical values $F_{12,8}$ =3.28 and $\frac{1}{F_{8,12}} = 0.35$ B1

$$\frac{s_B^2}{s_A^2} = 2.40 \left(\frac{s_A^2}{s_B^2} = 0.416\right)$$ M1A1

Since 2.40 (0.416) is not in the critical region we accept H_0 and conclude there is no evidence that the two variances are different. A1ft 5

(b) $$\text{Sp}^2 = \frac{8\times 1.02 + 12\times 2.45}{20}$$ M1

= 1.878 A1

$(27.94 - 25.54) \pm 2.086 \times \sqrt{1.878}\times\sqrt{\frac{1}{9}+\frac{1}{13}}$ B1M1 A1ft

(1.16, 3.64) A1 A1 7

	(c)	To calculate the confidence interval the variances need to be equal.		B1	
		In part (a) the test showed they are equal.		B1	2
					[14]
4.	(a)	$H_1 : \sigma_A^2 = \sigma_B^2 \qquad H_0 : \sigma_A^2 \neq \sigma_B^2$		B1	
		$S_A^2 = 22.5 \qquad S_B^2 = 21.6$	awrt	M1A1A1	
		$\dfrac{s_1^2}{s_2^2} = 1.04$		M1A1	
		$F_{(8, 6)} = 4.15$		B1	
		$1.04 < 4.15$ do not reject H_0. The variances are the same.		B1	8
	(b)	Assume the samples are selected at random, (independent)		B1	1
	(c)	$s_p^2 = \dfrac{8(22.5) + 6(21.62)}{14} = 22.12$	awrt 22.1	M1A1	
		$H_0: \mu_A = \mu_B \qquad H_1: \mu_A \neq \mu_B$		B1	
		$t = \dfrac{40.667 - 39.57}{\sqrt{22.12}\sqrt{\dfrac{1}{9} + \dfrac{1}{7}}}$		M1	
		$= 0.462 \qquad 0.42 – 0.47$		A1	
		Critical value $= t_{14}(2.5\%) = 2.145$		B1	
		$0.462 < 2.145$ No evidence to reject H_0. The means are the same		B1	7
	(d)	Music has no effect on performance		B1	1
					[17]
5.	(a)	$H_0: \sigma^2_F = \sigma^2_M \qquad H_1: \sigma^2_F \neq \sigma^2_M$		B1	
		$s^2_F = \dfrac{1}{6}(17956.5 - 7 \times 50.6^2) = \dfrac{33.98}{6} = 5.66333...$		B1	
		$s^2_M = \dfrac{1}{9}(28335.1 - 10 \times 53.2^2) = \dfrac{32.7}{9} = 3.63333...$		B1	
		$\dfrac{s^2_F}{s^2_M} = 1.5587...$ (Reciprocal 0.6415)		M1A1	
		$F_{6,9} = 3.37$ (or 0.24)		B1	
		Not in critical region. Variances of the two distributions are the same		A1	7
		need to have variance and the same o.e.			

(b) $H_0: \mu_F = \mu_M \quad H_1: \mu_F < \mu_M$ B1

Pooled estimate $s^2 = \dfrac{6\times 5.66333...+9\times 3.63333}{15}$ M1

$= 4.44533$

$s = 2.11$

$t = \dfrac{50.6-53.2}{2.11\sqrt{\frac{1}{7}+\frac{1}{10}}} = \pm 2.50$ M1A1

C.V. $t_{15}(5\%) = \pm 1.753$ B1

Significant. The mean length of the <u>females forewings</u> is less than the length of the males forewings A1 6

need female and forewing(wing)

[13]

6. (a) $\left(\bar{x} = \dfrac{466}{4} = 116.5\right)$

$S_{x^2} = \dfrac{54386-4\bar{x}^2}{3} = 32.\dot{3}$ or $\dfrac{97}{3}$ or awrt 32.3 M1 A1

$0.216 < \dfrac{3S_{x^2}}{\sigma^2} < 9.348$ B1 M1 B1

$10.376... < \sigma^2 < 449.07...$ awrt <u>10.4, 449</u> A1 A1 7

(b) $H_0: \sigma_m = \sigma_s \qquad H_1: \sigma_m > \sigma_s$

$H_0: \sigma_m^2 = \sigma_s^2 \qquad H_1: \sigma_m^2 > \sigma_s^2$ both B1

$\dfrac{S_{m^2}}{S_{s^2}} = \dfrac{318.8}{32.3} = 9.859...$ awrt 9.86 M1 A1

$F_{6.3}(17_0\,\text{c.v.}) = 27.91$ B1

9.15 < 27.91 A1ft 5

Insufficient evidence of an increase in variance

Insufficient evidence to say $\sigma_m^2 > \sigma_s^2$ is OK

Variance can be assumed to be the same is OK

[NB $\dfrac{32.3}{318.3} = 0.101...$ *only gets M1A1 <u>if</u> appropriate F value attempted.]*

[12]

7.	(a)	$(H_0 : \sigma_A{}^2 = \sigma_S{}^2 \quad H_1 : \sigma_A{}^2 \neq \sigma_S{}^2)$			
		$\frac{S_A^2}{S_S^2} = \frac{0.721^2}{0.572^2} = 1.588....$	awrt 1.59	M1 A1	
		$F_{8,9}(5\%)$ c.v. [= 10% 2tail] = 3.23		B1	
		Not significant, can assume variances are equal		B1 c.a.o.	4
		(accept $\sigma_A^2 = \sigma_S^2$)			
	(b)	$Sp^2 = \frac{8 \times 0.721^2 + 9 \times 0.572^2}{8+9} = 0.41784...$	M1 A1		
		0.417… or awrt 0.418			
		$t_{17} = (2.5\%)$ c.v. $= 2.110$		B1	
		95% C.I. $= \bar{x}_B - \bar{x}_A \pm 2.110 \times Sp \times \sqrt{\frac{1}{9} + \frac{1}{10}}$		M1	
		$= 0.02 \pm 2.110 \times \sqrt{0.417...} \times \sqrt{\frac{1}{9} + \frac{1}{10}}$		A1ft	
		= (–0.6066… , 0.6466….)	awrt (–0.607, 0.647)	A1, A1	7
	(c)	± 0.7 is outside interval		B1ft	
		$\therefore$ Manager need <u>not</u> be concerned	(dep)	B1ft	2
		(allow ft if 0.7 inside)			

[13]

8.	(a)	$s_A{}^2 = 5.11$, $5_B{}^2 = 5.14$		B1 B1	
		H_0: $\sigma_A{}^2$, H_1: $\sigma_A{}^2 \neq \sigma_B{}^2$		B1	
		Critical value $F_{6,\,8} = 3.58$		B1	
		$\frac{s_B{}^2}{s_A{}^2} = 1.0062112 ...$	awrt 1.01	M1 A1	
		No evidence to reject H_0. The variances are equal.		A1	7

	(b)	$s_p^{\,2} = \dfrac{8\times5.14+6\times5.11}{9+7-2} = 5.1247$ awrt 5.12	M1 A1		
		$\mu_A = 14.11\ ..\ ,\ \mu_B = 11.857\ ..$			
		$H_0 : \mu_A = \mu_B\ ,\ H_1 : \mu_A > \mu_B$	B1		
		Critical value t_{14} (5%) = 1.761	B1		
		$T = \dfrac{14.11..-11.857...}{\sqrt{5.1247...\left(\frac{1}{9}+\frac{1}{7}\right)}} = 1.9757$ awrt 1.98	M1 A1		
		There is evidence to reject H_0. Mean time taken from school A is greater than school B.	A1	7	
	(c)	Equal variances are a condition for the test in part(b)	B1	1	
	(d)	Groups not equal ability	B1	1	
					[16]
9.	(a)	$P(X > 19.023) = 0.025$ or $P(X < 19.023) = 0.975$	both B1		
		$P(X > 2.088) = (0.990$ or $P(X < 2.088) = 0.010$			
		$\therefore P(2.088 < X < 19.023) = 0.990 - 0.025$ or $0.975 - 0.010$	M1		
		$= \underline{0.965}$	A1	3	
	(b)	Upper Critical value of $F_{12,5} = 4.68$	B1		
		Lower Critical value of $F_{12,5} = \dfrac{1}{F_{5,12}}$	M1		
		$= \dfrac{1}{3.11} = 0.3215\ldots$	A1	3	
		awrt 0.322			
					[6]

10.	(a)	H_0: $\sigma_2^2 = \sigma_2^2$; H_1: $\sigma_1^2 \neq \sigma_2^2$	both B1	
		$\frac{s_1^2}{s_2^2} = \frac{14^2}{8^2} = \underline{3.0625}$ or $\frac{8^2}{14^2} = 0.32653\ldots$	M1 A1	
		awrt 3.06 or 0.327		
		C.V. $F_{12,7} = 3.57$ C.V.: $F_{7,12} = \frac{1}{3.57} = 0.28011$	B1	
		Since 3.0625 is not in the Critical Region there is insufficient evidence to reject H_0. There is insufficient evidence of a difference in the variances of the length of the fence posts.	A1ft	5
	(b)	The distribution of the population of lengths of fence posts is normally distributed.	B1	1

[6]

11.	H_0: $\sigma^2 = 4$; H_1: $\sigma^2 > 4$	B1
	both	
	$\upsilon = 19$, X_{19}^2 (0.05) = 30.144	B1
	$\frac{(n-1)S^2}{\sigma^2} = \frac{19 \times 6.25}{4} = 29.6875$	
	use of $\frac{(n-1)S^2}{\sigma^2}$	M1
	AWRT 29.7	A1
	Since 29.6875 < 30.144 there is insufficient evidence to reject H_0.	A1 ft
	There is insufficient evidence to suggest that the standard deviation is greater than 2.	B1 ft

[6]

12. (a) $S_A^2 = \frac{1}{10}\{3960540 - \frac{6600^2}{11}\} = \underline{54.0}$ B1

$S_B^2 = \frac{1}{12}\{7410579 - \frac{9815^2}{13}\} = \underline{21.1\dot{6}}$ B1

H_0: $\sigma_A^2 = \sigma_B^2$; H_1: $\sigma_A^2 \neq \sigma_B^2$ B1

CR: $F_{10,\,12} > 2.75$

$S_A^2 / S_B^2 = \frac{54.0}{21.1\dot{6}} = 2.55118\ldots$ M1 A1

Since 2.55118… is not in the critical region, we can assume that the variances of A and B are equal. B1 6

(b) H_0: $\mu_B = \mu_A + 150$; H_1: $\mu_B > \mu_A + 150$ B1

both

CR: $t_{22}(0.05) > 1.717$ B1

$S_p^2 = \frac{10\times 54.0 + 12\times 21.1\dot{6}}{22} = \underline{36.0\dot{9}\dot{0}}$ M1 A1

$t = \frac{1755 - 6001 - 150}{\sqrt{36.0909\ldots\left(\frac{1}{11}+\frac{1}{13}\right)}} = \underline{2.03157}$ M1 A1

AWRT 2.03 A1

Since 2.03… is in the critical region we reject H_0 and conclude that the mean weight of cauliflowers from *B* exceeds that from *A* by at least 150g. A1 ft 8

(c) Samples from normal populations B1 B1 2

Any two sensible verifications

Equal variances

Independent samples

[16]

13. (a) H_0: $\sigma_A^2 = \sigma_B^2$, H_1: $\sigma_A^2 \neq \sigma_B^2$ both B1

critical values $F_{24.25} = 1.96$ and $\frac{1}{F_{24.25}} = 0.510$ both B1

$\frac{s_B^2}{s_A^2} = 2.10$ or $\frac{s_A^2}{s_B^2} = 0.476$ both M1 A1

Since 2.10 or 0.476 are in the critical region we reject H_0 and conclude there is evidence of a difference in variability of pebble length between area A and B A1∫ 5

(b) The populations of pebble lengths are normal. B1 1

[6]

1. This proved to be a good starter question and most candidates gave good solutions.

Part (a) was answered well with many candidates gaining full marks.

In part(b) although a pooled estimate was worked out correctly by many candidates they then failed to use the square root of it in their calculations of the confidence interval or they used $\sqrt{\frac{21.53}{15}}$ rather than $\sqrt{21.53\left(\frac{1}{8}+\frac{1}{7}\right)}$. A few candidates found the confidence intervals for the mean times separately rather than for the difference.

2. The most able candidates gained full marks for this question. In part (b) a minority of candidates tested whether the variances of the two cars were equal rather than testing whether the variance of the Panther car was equal to 16.

3. Part (a) was answered well with many candidates gaining full marks. In part (b) although a pooled estimate was worked out correctly by many candidates they then failed to use the square root of it in their calculations of the confidence interval.

In part (c) candidates knew that to find the confidence interval/pooled estimate that the variances needed to be equal but few commented on the fact that this has been established in part (a).

4. This question was answered well with a large proportion of the candidates getting full marks. In part (b) many candidates stated that the marks were normally distributed which was not an assumption they had made as it had been stated in the question.
In part (c) the pooled estimate was worked out correctly by many candidates but they then failed to use the square root of it in their calculations of t. Many candidates were able to draw a conclusion in the context of the question.

5. This question was well answered with a large proportion of the candidates getting full marks. In part (b) the pooled estimate was worked out correctly by many candidates but they then failed to use the square root of it in their calculations of t. Many concluded that females were shorter than males rather than it being the forewing length which was shorter

6. Most realized that the Chi squared distribution was required to establish the confidence interval in part (a) and there were many correct solutions. The *F* test was usually used in part (b) but sometimes the degrees of freedom were the wrong way around and some used a 5% significance level.

7. The two tailed *F* test was usually tackled quite well but the confidence interval in part (b) was not. A pooled estimate of variance $s_p^{\,2}$ was required and this was often attempted but the $\sqrt{\frac{1}{9}+\frac{1}{10}}$ term sometimes divided into s_p rather than multiplying it. The interpretation in part(c) was often answered well and the follow through enabled those who could interpret the statistics to gain some credit.

8. Candidates found this question very demanding and parts (a) and (b) were usually confused and incoherent due to accuracy errors.

9. Many candidates were able to answer this question correctly but too many showed that they had not understood the *F*-distribution tables. A clear shaded and labelled diagram would have helped many candidates.

10. Although generally well answered common errors were the division of the standard deviations; confusing the degrees of freedom and hence finding the wrong critical value; not giving the conclusion in context and not making reference to the population in the final part.

11. This question was generally very well answered. Weaker candidates sometimes confused the unbiased estimate of the population variance with the given population value and they often forgot to relate their conclusion to the context of the question.

12. Many of the candidates scored full marks in part (a). In part (b) too many of them could not specify the hypotheses correctly since they did not know how to cope with the 150g. Surprisingly many of the candidates did not score both marks in the final part of this question.

13. The question proved to be a friendly starter for the majority, with many candidates gaining full marks. The most common error was in the conclusion where the context was omitted.