GENERAL COMMENTS

Six-thousand and ninety-three students sat for the 2002 examination, 169 more than the number (5924) in 2001, an increase of about 3%. As in 2001, students were required to answer 30 multiple-choice questions in Part I, and six questions worth a total of 20 marks in Part II.

The 2002 examination proved to be more accessible to many students. The mean score (out of 30) for Part I was 19.63, up from 16.82 in 2001. The number of questions answered correctly by less than 50% of students was 4, down from 10 in 2001. Similarly, for Part II the mean score (out of 20) was up from 8.18 in 2001 to 10.74 in 2002, and the number of question parts for which the mean score was less than 50% of the maximum possible was down from 7 (out of 8) to 2 (out of 7).

The overall mean and median scores (out of 50) were 29.5 and 30 respectively, compared with 24.8 and 24 in 2001. About 6% of students, well down from 15% in 2001, scored less than 25% of the available marks. The lowest score was 2 out of 50, obtained by four students, compared with 1 obtained by three students in 2001. About 6% of students scored more than 90% of the available marks (compared to about 4.4% in 2001 and about 3% in both 1999 and 2000).

However, only 8 students scored full marks, compared with 27 in 2001 (but only 4 in 2000). Students, who otherwise would have obtained perfect scores, commonly missed out on the last mark in one or more of Questions 1b, 4, 5 and 6 in Part II. In Part I, Question 9 proved unexpectedly difficult.

There was a much smaller proportion than usual of ‘no attempts’, or almost ‘no attempts,’ at Part II. This is reflected in the improved performance overall on Part II and may indicate that students were able to move more readily through Part I than in previous years. The number of students who exhibited poor algebraic skills continues to be of concern. This was particularly evident in the handling of surds and fractions in Questions 5 and 6, respectively.

Some students clearly disregarded the direction on the front page of the paper not to bring white out liquid/tape into the examination room, and wasted valuable time ‘whiting out’ attempts at questions. It was pleasing that most students used a pen to answer Part II and this should be encouraged – although it is wise to recommend using a pencil to draw graphs.

An analysis of the responses to Question 14 of Part I (see below) indicates that students used their graphics calculators effectively. However, it was clear from answers to Question 6 of Part II that many students do not recognise *when* it is appropriate, or even when it is allowable, to use a graphics calculator. Teachers should ensure that students realise that, in the absence of explicit instructions indicating otherwise (such as ‘Find the **exact** value of …’ or ‘**Use calculus** to …’), students are free to use their graphics calculators as applicable. They should recognise possible indicators as to when calculator use is suitable, such as ‘Find, *correct to two significant figures* …’. Students should use a graphics calculator when it provides an effective means of obtaining a solution without regarding it as only a method of last resort.

Another feature of many answers to Question 6 of Part II was the failure to recognise that acceleration is not constant and so constant acceleration formulas were not appropriate. Using constant acceleration formulas when it is *not* appropriate, as also often happened in Question 2, is an ongoing concern that needs particular attention from teachers and students.

Many students failed to complete solutions properly in Part II because of poor algebraic skills. This occurred particularly with Questions 5 and 6, but also with Questions 1a, 2 and 3.

A disturbing trend is for students to perform less well on complex number questions than on questions from other areas of the syllabus. There was no complex number question in Part II of examination 1 in 2002, but two of the four complex number questions (Questions 7 and 9) were the least well answered questions in Part I, and the complex number question in Examination 2 (Question 5) was also less successfully done, even allowing for it being the last question on the paper. Students require sound algebra skills and the ability to relate complex numbers to curves and geometric forms in the complex plane, to tackle this topic effectively.

SPECIFIC INFORMATION

Part 1 – Multiple-choice questions

This table indicates the approximate percentage of students choosing each distractor. The correct answer is the shaded alternative.

Question	A	B	C	D	E
			%		
1	3	6	5	4	82
2	4	17	74	4	1
3	14	2	7	56	21
4	57	20	10	8	5
5	3	3	1	3	90
6	71	6	4	3	16

Question	A	B	C	D	E
			%		
16	6	14	8	6	66
17	6	11	10	69	4
18	9	53	18	4	16
19	10	12	9	63	6
20	67	7	12	8	6
21	18	48	12	13	9

7	17	43	23	12	5	**22**	75	6	10	6	3
8	3	6	5	82	4	**23**	3	6	71	13	7
9	14	29	15	8	34	**24**	8	13	62	13	4
10	4	6	83	6	1	**25**	8	79	4	6	3
11	67	9	14	6	4	**26**	3	8	8	74	7
12	2	4	5	15	74	**27**	3	4	43	4	46
13	7	3	69	17	4	**28**	16	7	58	8	11
14	70	12	9	2	8	**29**	1	7	69	8	15
15	5	60	10	17	8	**30**	6	4	13	66	11

The mean score of the sample was 19.63 and the standard deviation was 6.47. Only four questions (7, 9, 21 and 27) were answered correctly by less than 50% of students. Some of the questions considered to be the more challenging (e.g. 20, 29 and 30) were well done. Interestingly, five of the six questions on which performance best correlated with overall performance involved carrying out calculus techniques (Questions 11, 12, 16, 17 and 22, with Question 20 being the other such question).

Question 9 was by far the least well answered question. In addition, it was the only question in which a distractor (E) was more popular than the correct answer (B). Undoubtedly option E is an attractive distractor, but it was not anticipated. In retrospect, its presence made the question a test of set notation as well as complex number theory.

Question 7 was a second complex number question that was answered correctly by a minority of students. Options C and D were popular, indicating that a significant proportion of students continue to be confused as to the modulus and argument of a negative number. Those students who chose option A, apparently calculated $(-2i)^2 = 4$.

Question 21 required careful consideration of what relationship must exist between the position vectors of three collinear points. Not surprisingly, option A was a popular distractor. This condition holds if *P*, *Q*, *R and O* are collinear, but it is not a *sufficient* condition for *P*, *Q*, and *R* to be collinear as in general it only indicates that *OS* is parallel to *PQ*. As each of the three remaining distractors was chosen by similar percentages of students, it seems that many students guessed their answer to this question.

In Question 27, although the popularity of distractor C, where friction acts in the same direction as the applied force, was not necessarily unexpected, it is worrying that many students thought that diagram E could be a correct representation of forces acting on a particle resting on an inclined plane. Teachers should ensure that students understand why this cannot be so, and why each of the other situations *is* possible.

Two questions that were answered correctly by more than 50% of students deserve further investigation because of the popularity of at least one of their distractors. In Question 3 many students chose distractor E, apparently not noticing the lack of asymptotic behaviour. In Question 18 students incorrectly chose option C and E, indicating incorrect interpretation of the three-dimensional situation. Both of these questions were written to follow up common errors on the Examination 2 in 2001 (Questions 3a and 1ci) and so it might have been expected that responses would have been more successful.

Finally, it is informative to analyse the responses to Question 14, which required students to use their graphics calculator to evaluate $\int_0^1 \frac{x^2-2x}{2\cos x}\,dx = \int_0^1 \frac{(x^2-2x)}{(2\cos(x))}\,dx$. The students who chose E entered the integrand correctly, but either reversed the terminals or (more likely) changed the sign of their answer believing it had to be positive (a common mistake in Question 2c of Part II last year). Students who chose B entered the integrand correctly, but had their calculator in degree mode. Students who selected C and D did not use parentheses appropriately (C), or at all (D), when entering the integrand. They obtained the values of $\int_0^1 \frac{(x^2-2x)}{2}\cos(x)\,dx$ and $\int_0^1 (x^2 - \frac{2x}{2}\cos(x))\,dx = \int_0^1 (x^2 - x\cos(x))\,dx$, respectively.

Part 2 – Short-answer questions

Question	Marks	%	Response
Question 1	**a** 0/2 1/2 2/2 (Average mark 1.44)	 18 20 62	Answer: $\frac{(x+1)^2}{1} + \frac{(y-2)^2}{9} = 1$ Well done, but not as well as could be expected given that the general equation for an ellipse is given on the formula sheet. A large number of students made errors such as omitting ‘= 1’, failing to square one or both terms, or writing $(x + 1)^2$ as $x^2 + 1$.
	b 0/2 1/2 2/2	 21 65 14	Answer: Dilation by a factor of 3 away from the *x*-axis, *followed by* a translation of 1 in the negative *x* direction and 2 in the positive *y* direction. Not done well. Most students were able to describe the translation

	(Average mark 0.93)	correctly, in one way or another, but many had trouble describing the dilation, sometimes even referring to an increase in the 'radius' of the ellipse. The major mistake, however, was that most students described the translation as taking place *before* the dilation. It is likely that many of these students gave no thought to the order of transformations at all, not recognising that this is critical in this case.
Question 2	0/3 30 1/3 10 2/3 6 3/3 54 (Average mark 1.84)	Answer: $T = 25$ Well done by students equating areas, though some students had difficulty calculating the area under the car graph. Others made simple algebraic or arithmetic slips, or had trouble with the time scale and used $T + 60$ as the total time. Many students unsuccessfully attempted to use constant acceleration formulas (e.g. putting $u = 24$, $v = 0$ and $t = 60$ for the car).
Question 3	0/2 39 1/2 17 2/2 44 (Average mark 1.04)	Answer: $\dfrac{2}{\cos\left(\frac{x}{2}\right)} + c$ Most students made the correct substitution, $u = \cos\left(\frac{x}{2}\right)$ but many then made a sign error or other simple errors and obtained an answer of the form $\dfrac{k}{\cos\left(\frac{x}{2}\right)}$, where $k = -2, \pm 1, \pm\frac{1}{2}$. Common time-consuming errors were to substitute $u = \sin\left(\frac{x}{2}\right)$, or to try and 'simplify' the integrand by using double angle formulas. As usual with a quotient integrand, some students gave answers involving the natural log of the denominator.
Question 4	0/4 27 1/4 11 2/4 8 3/4 26 4/4 28 (Average mark 2.17)	Answer: Each possible graph of the function f must have (only) two stationary points: a local maximum at $x = 3$ and a *stationary* point of inflexion at $x = 1$. The two graphs should have identical shapes, with one being obtained from the other by a translation in the positive or negative y direction. Most students sketched a graph with a local maximum at $x = 3$, but few of these graphs had an obvious *stationary* point of inflection at $x = 1$. Apparently, many students just drew a 'general' point of inflexion, not realising that it had to have zero gradient. Many students either did not realise that their second graph should be 'parallel' to their first graph, or did not take enough care in ensuring that this was the case. Some students wasted a lot of time trying to find an expression for $f'(x)$, so that they could find $f(x)$, rather than deducing the graph of f from the graph of f' by consideration of the stationary points of f.
Question 5	0/4 15 1/4 8 2/4 30 3/4 26 4/4 21 (Average mark 2.28)	Answer: $a = -\sqrt{6}$ It was pleasing to see that most students obtained $\underset{\sim}{u}.\underset{\sim}{v} = -a$, although some made a sign error and obtained $2-a$ or a. Many students also obtained $\underset{\sim}{u}.\underset{\sim}{v} = \sqrt{3}\sqrt{2+a^2}\cos(60°)$, but then had trouble working with $\sqrt{2+a^2}$. Common errors were to simplify it to $\sqrt{2}+a$ or $\sqrt{2}\,a$. Nearly half the students got as far as $a^2 = 6$, but over half of these gave their answer as either $a = \pm\sqrt{6}$ or $a = \sqrt{6}$. Students should be reminded that 'solutions' obtained by squaring a surd equation need to be verified.
Question 6	0/3 45 1/3 22 2/3 7 3/3 26 (Average mark 1.14)	Answer: 1.7 s Not well done. Common student errors were: using $v = u + at$, with $u = 3$, $v = 10$ and $a = -2+\sqrt{v^2+5}$; trying to use $a = v\dfrac{dv}{dx}$ instead of $a = \dfrac{dv}{dt}$; writing and 'evaluating' $v = \int_3^{10}(-2+\sqrt{v^2+5})\,dt$; writing the reciprocal of

		$-2+\sqrt{v^2+5}$ as $\dfrac{-1}{-2+\sqrt{v^2+5}}$, or (very commonly) as $-\dfrac{1}{2}+\dfrac{1}{\sqrt{v^2+5}}$; and failing to use their graphics calculator to evaluate the solution integral $\int_3^{10}\dfrac{-1}{-2+\sqrt{v^2+5}}\,dv$. However, it was pleasing to note that students who obtained the correct integral and did use their graphics calculator to evaluate it invariably did so correctly.