Coimisiún na Scrúduithe Stáit
State Examinations Commission

Junior Certificate Examination 2006

Mathematics

CHIEF EXAMINER'S REPORT FOUNDATION LEVEL

CHIEF EXAMINER'S REPORT ORDINARY LEVEL

CHIEF EXAMINERS REPORT HIGHER LEVEL

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MATHEMATICS

1. GENERAL INTRODUCTION

The State Examinations Commission offers Junior Certificate examinations in Mathematics at three levels – Higher, Ordinary and Foundation.

The aims of the Junior Certificate Mathematics syllabus for all levels state that Mathematics education should:

- Contribute to the personal development of the student.

- Help to provide students with the mathematical knowledge, skills and understanding needed for continuing their education, and eventually for life and work.

These aims are translated into the following general objectives:

a. Students should be able to *recall* basic facts.
b. Students should be able to demonstrate *instrumental understanding*.
c. Students should have acquired *relational understanding*.
d. Students should be able to *apply* their knowledge of facts and skills.
e. Students should be able to *analyse* information, including information presented in cross-curricular and unfamiliar contexts.
f. Students should be able to *create* mathematics for themselves.
g. Students should have developed the *psychomotor* skills necessary for the realisation of the above objectives.
h. Students should be able to *communicate* mathematics, both verbally and in written form.
i. Students should *appreciate* mathematics.
j. Students should be *aware* of the history of mathematics and hence of its past, present and future role as part of our culture.

To support the above aims and objectives of the Junior Certificate Mathematics Syllabus, the Junior Certificate Mathematics Support Service was set up to provide additional professional development for teachers of mathematics and to supplement this with workshops where local needs exist. The Junior Certificate Mathematics Support Service was launched in September 2000. In 2006, the service was extended to give general support and now operates as the Maths Support Service.

Presentations and materials of the Support Service may be accessed at the website: www.mathssupport.ie/

Comprehensive Marking Schemes for mathematics give a clear indication of the standard and quality of work needed to achieve particular grades.

The Marking Schemes are available in the "Examination Material archive" of the State Examinations Commission's website: www.examinations.ie

1.1 THE SYLLABUS

The Higher, Ordinary and Foundation Mathematics syllabi for the Junior Certificate were introduced (as intermediate certificate syllabi, entitled "Syllabus A", "Syllabus B", and "Syllabus C", respectively) in 1987, for first examination in 1990.

Some amendments have been made to the content, and the amended versions are presented in the booklet "Junior Certificate Mathematics Syllabus"

The revised syllabus was introduced in September 2000.
It was examined for the first time in June 2003.

The NCCA is currently conducting a review of post-primary mathematics education.

Sample papers at all three levels were issued to all second-level schools. Guidelines for Teachers were also issued in conjunction with the introduction of the revised syllabus.

The Syllabus and the Guidelines for Teachers are available on the website of the Department of Education and Science, at: http://www.education.ie

The use of calculators in the Junior Certificate Examination was allowed for the first time in 2003. The Department of Education and Science issued a set of guidelines on the use of calculators to every second-level school. This document was prepared in co-operation with the National Council for Curriculum and Assessment (NCCA), and includes a chapter on the use of calculators in the certificate examinations. The Document is available on the Department of Education and Science website.

Rule 74 in *Rules and Programme for Secondary Schools* governs the use of scientific, non-programmable calculators in the Certificate Examinations. Some recent advances in calculator technology have led to a possible lack of clarity regarding the features that are permissible in calculators for use in the examinations. Accordingly, the relevant rule was amended in order to reflect the intention of the original rule in light of more recent advances and this amendment was notified to schools under circular letter S 93/05. This circular may be accessed on the State Examinations Commission website at: http://www.examinations.ie

1.2 The Examination

Structure of the Examination for Foundation Level

The examination consists of one paper, comprising six questions. All questions must be attempted to obtain full marks. Each question carries 50 marks. The duration of the examination is 2 hours. The question paper is the answer book.

Structure of the Examination for Ordinary Level

The examination consists of two papers, each comprising six questions. All questions must be attempted on each paper to obtain full marks. Each question carries 50 marks. The duration of each paper is 2 hours. In each case, the question paper is the answer book.

Structure of the Examination for Higher Level

The examination consists of two papers, each comprising six questions. All questions must be attempted on each paper to obtain full marks. Each question carries 50 marks. The duration of each paper is 2 hours, 30 minutes.

Candidate Numbers and Percentages

The following table shows the number of candidates taking each level of the subject in 2006 and over the preceding three years. The number of candidates taking each level is also given as a percentage of the total number of candidates taking Mathematics for that year. The number of candidates taking Junior Certificate Mathematics increased from 2005 by 1152, an increase of 2·1%. The percentage taking Higher Level Mathematics increased to 42·5%.

Year	2003	2004	2005	2006
Total number of Mathematics Candidates	58440	55937	55813	56965
Number of Candidates at Higher Level	23734	23006	23388	24204
(as a % of total number taking Mathematics)	(40·6)	(41·1)	(41·9)	(42·5)
Number of Candidates at Ordinary Level	27382	26347	26518	26820
(as a % of total number taking Mathematics)	(46·9)	(47·1)	(47·5)	(47·1)
Number of Candidates at Foundation Level	7324	6584	5907	5941
(as a % of total number taking Mathematics)	(12·5)	(11·8)	(10·6)	(10·4)

2. FOUNDATION LEVEL

2.1 Introduction

- The Examination consists of one paper, comprising six questions.
  All questions must be attempted to obtain full marks**.**
  Each question carries 50 marks.
  The duration of the paper is 2 hours.
  The 'Pen-in-Hand (✍)'symbol indicates that supporting work must be shown for full marks.
  The question paper is the answer book.

- A total of 5941 Junior Certificate Foundation Level Mathematics scripts were assigned to, and marked by, sixteen Assistant Examiners and two Advising Examiners .

- There was general agreement among Advising Examiners and Assistant Examiners that the 2006 Junior Certificate Foundation Level Mathematics Paper was balanced, well designed and well structured. The content was wide-ranging, adequately-challenging and thought-provoking for participating candidates. The written instructions, diagrams, syntax, symbolism and readability-level of the examination questions were deemed appropriate for this paper.

- Most of the participating candidates engaged successfully with the content of the examination paper and this resulted in high numbers attaining grades A, B, C and D.

2.2 Performance of Candidates

The following table shows the percentage of candidates achieving each grade in 2006.

2006 Total Number of Candidates: 5941							
Grades	A	B	C	D	E	F	NG
Percentage of Candidates	17·1	37·8	29·0	13·7	2·1	0·4	0·0

The average mark per question and its topic is shown in the table below.

Question	**Average Mark**	**Topic**
1	46·5	Applied Arithmetic
2	33·5	Statistics
3	30·2	Geometry
4	37·7	Sets and Applied Arithmetic
5	37·3	Algebra:Functions and Graphs
6	27·2	Measure

2.3 Analysis of Candidate Performance

Question 1 Average mark: 46·5

Question 1 was a very well answered question, with the majority of candidates getting 47 or 50 marks overall. This question was attempted by 100% of candidates.

(a) **(i)** This section was very well answered. Errors were extremely rare.

(ii) This section was very well answered. Errors were extremely rare.

(b) **(i)** This section was very well answered. Errors were extremely rare.

(ii) This section was very well answered. Errors were extremely rare.

(iii) This section was very well answered. Errors were extremely rare. A minority of candidates avoided this section or provided an incorrect answer with no supporting calculations. The answer 128 or 32, without supporting work, was presented on occasions.

(iv) This section was very well answered. Errors were rare.
Some candidates avoided this section or provided an incorrect answer with no supportive calculations. The answer 12 or 27 or 64, without supporting work, was presented on occasions.

(c) **(i)** This section was extremely well answered by most candidates. The most common error encountered in this section was an arithmetic error in performing calculations or when the candidate did not use the prescribed multiple of items in calculations.

(ii) This section was very well answered by most candidates. The most common error encountered in this section was an arithmetic or decimal error.
The penalty for failure to show supporting work was frequently activated in this section. Some candidates presented the subtraction algorithm in reverse order, but carried out the operation in correct sequence.

Question 2 — Average mark: 33·5

(a) This section was very well answered by most candidates. Some candidates attempted to find a solution by rearranging the components in ascending or descending order. Other candidates attempted to get the mean of the components. Incorrect answers without work were also presented.

(b) **(i)** This section was very well answered. The most common error here was failure to multiply by two.

(ii) This section was very popular and it was well answered. Some candidates incurred the 'Pen-in-Hand' symbol penalty by simply writing 20, without presenting accompanying calculations. Some candidates omitted a component from their total. Other candidates did not multiply by two and presented 10 as their answer.

(iii) This section was not very well answered. Most candidates were successful in identifying a valid component and so attained the attempt mark. The most common errors observed were: use of incorrect numerator; use of incorrect denominator; inversion of components and omission of components. A range of incorrect answers without supportive work were presented.

(c) This section was even less well answered. The construction of an accurate pie chart was often constrained by the candidate's inability to perform the correct mathematical operations with the raw data. The absence of relevant mathematical calculations was one of the major areas of error. Many candidates merely plotted the raw data, some successfully within tolerance but many were unable to sketch the segments successfully. The utilisation and placement of valid labels ("French", "German" and "Spanish") was generally good. There was some evidence that some candidates did not possess the relevant geometrical equipment to construct the pie chart and its component segments.

Question 3 Average mark: 30·2

This was a poorly answered question, with a significant number of candidates failing to attempt some parts of it.

(a) This section was very well answered by most candidates. Many candidates ignored the 'Pen-in-Hand' symbol and merely wrote 30^{O}. Many candidates entered 30^{O} appropriately into the diagram. There was little or no evidence of candidates employing a protractor to measure the missing angle. Some candidates gained marks for identifying a valid component (360^{O}, 180^{O}, 90^{O}).

(b) **(i)** This section was well answered by most candidates. Some candidates drew a triangle which may or may not have included a right angle. There was some evidence of freehand drawing here.

(ii) This section was fairly well answered by most candidates. A minority of candidates avoided this section and provided no answer. Some candidates provided an answer that was outside tolerance.

(c) **(i)** This section posed considerable difficulty for many candidates. A low percentage of candidates achieved full marks in this section. Many candidates simplistically used a measurement technique and attempted to measure the length of the hypotenuse. Some candidates performed an operation with the given components including $9 + 12 = 21$ or $9 \times 12 = 108$. Some candidates presented the trigonometric formulae as their solution. Some candidates were successful in performing squaring and successfully calculated 81 and 144. However the subsequent step of getting the square root posed significant difficulty for many candidates. There was some evidence that candidates possessed the knowledge that 9, 12 and 15 were linked in sequence.

(ii) This section was not very successfully answered by most candidates. The most common incorrect solution here was the construction of some arc or the drawing of a line connecting *a* to *c*. Some candidates merely reproduced the given diagram, without any additional construction attached, as their solution.

Question 4 — Average mark: 37·7

This section was reasonably well answered, with part (b) being answered very well, as were parts c (i) and c (ii). Some candidates had problems with finding the take-home pay.

(a) This section was fairly well answered by many candidates. Some candidates did not have to rely upon supporting calculations to arrive at a correct solution. Other candidates presented 25 as their solution. Other incorrect "Special Case" solutions presented were: $1 \cdot 4$ and $4 \cdot 1$. A range of incorrect answers, without supporting work, was also provided.

(b) **(i)** This section was very well answered by most candidates. The candidates' selection of the correct elements was certainly supported by the availability of the answer grid, which indicated the number of elements required in the solution.

(ii) This section was very well answered by the candidates. The candidates' selection of the correct elements was certainly supported by the availability of the answer grid, which indicated the number of elements required in the solution.

(iii) This section was very well answered by most candidates. The candidates' selection of the correct symbol was supported by the availability of the answer grid. Some candidates interchanged the symbols and so attained a combined attempt mark.

(iv) This section was very well answered by most candidates. The candidates' selection of the correct symbol was supported by the availability of the answer grid.

(c) **(i)** This section was very well answered by most candidates. Some candidates incurred the 'Pen-in-Hand' symbol penalty for not presenting accompanying calculations.

(ii) Many candidates were successful in arriving at the correct answer in this section. However, some candidates had difficulty in applying 20% leading to inappropriate inversions of components, omitting of components or working with an incorrect fractional representation of 20%. Some candidates used their calculator, without supporting calculations, to arrive at the correct solution and so incurred the 'Pen-in-Hand' symbol penalty.

(iii) This section posed significant difficulty for many candidates. These candidates encountered difficulty in performing the two integral operations and often stopped after performing one operation and omitted the final step. $385 - 52 = 333$ was typical of a range of the genre of work presented. Some candidates attained marks in this section by the successful recognition of a valid component.

Question 5 Average mark: 37·3

This question was reasonably well answered, with part (c) answered very well.

(a) This section was well answered by most candidates. Some candidates avoided this section completely. Some candidates incurred the 'Pen-in-Hand' symbol penalty. The usual genre of mathematical errors occurred in candidates' work including 5 + 3 + 2 = 10 or 53 + 2 = 55 or 125 + 2 = 127. A range of incorrect answers, without supporting calculations, were supplied in this section.

(b) **(i)** This section was very well answered by most candidates. Many candidates arrived at the correct solution without providing supportive calculations. Many candidates arrived at their solution by successful trial and error. Some incorrect spurious numbers were also observed.

(ii) This section was fairly well answered by most candidates. Some candidates had difficulty applying and performing the distribution and transposition rules correctly and effectively. Consequently the most common errors in this section were those involving transposition of elements and the application of the distribution law of multiplication. Many correct solutions were arrived at by the successful manipulation of the trial and error technique.

(c) **(i)** This section was well answered by most candidates and no candidate incurred the 'Pen-in-Hand' symbol penalty because of the availability of the new calculator with its additional array of functions. Some candidates inadvertently calculated the range of values for ($y = 4x$) instead of ($y = x + 4$). Some candidates succeeded in calculating the correct values for y but entered them in reverse order into the table.

(ii) This section was very well answered by most candidates. Errors included: incorrect plotting of points; the failure to join the plotted points with a line; the drawing of a bar chart instead of a line graph.

Question 6 Average mark: 27·2

This was not a well answered question and many failed to attempt any part of it.

(a) **(i)** This metric conversion, posed significant difficulty for many candidates. Mathematical errors were incurred because the candidate used a multiple other than 1000 to perform the conversion. A range of incorrect answers, without supporting work, were provided by the candidates.

(ii) This metric conversion posed significant difficulty for many candidates. Mathematical errors were incurred because the candidate used a multiple other than 100 to perform the conversion. A range of incorrect answers, without supporting work, were provided by the candidates.

(b) **(i)** This section was very well answered by many candidates. The generosity of permitting the candidate to measure $|AB|$ within a 1 cm tolerance ensured that many candidates got full marks in this section. Evidence of candidate measurement was often detected within the diagram. Many candidates did not supply evidence of performing written calculations but merely entered 120 as their solution. Some candidates omitted multiplication by 20.

(ii) This section posed considerable difficulty for many candidates. These candidates often failed to carry forward their solution from part b(i) and to integrate it into their subsequent calculations. Some candidates included $|AC|$ in their calculations. Other errors included: failure to multiply by 20; failure to finish and failure to indicate addition.

(c) **(i)** This section posed significant difficulty for some candidates but was generally very well answered. A candidate who was not aware of the correct relationship between diameter and radius often employed multiplication by two to get his/her solution. A range of incorrect answers, without accompanying calculations, were also presented.

(ii) This section was fairly well answered by candidates. Among the errors observed in this section were: use of an incorrect operator; omitting part of a component; incorrect substitution and arithmetical errors in performing the calculations.

2.4 Conclusions

- Overall, the 2006 Junior Certificate Foundation Level Maths Paper was considered to be candidate friendly and adequately-challenging to assess and determine the level of mathematical knowledge and skills possessed by the candidates.

- The examination paper contained no major complexities and was a suitable vehicle whereby participating candidates had adequate opportunities to display their skills, insights and knowledge of the Junior Certificate Foundation Level Maths Syllabus, and in so doing to attain examination success.

- The examination paper was successful in assessing the candidates' level of competency in performing computational and numerical operations and in determining their level of knowledge of a range of the important mathematical concepts which are prescribed in the Junior Certificate Foundation Level Syllabus.

- The linguistic complexity, computational complexity and analytical complexity of the examination questions were regarded as being appropriate for the paper.

- In the 2006 examination, twenty two 'Pen-in-Hand' symbols were utilised, each with a consistent blunder (-3) level of penalty attached. The candidate, who ignored each of the 'Pen-in-Hand' symbols, would suffer a total loss of 66 marks. A great number of marks were lost as a consequence of candidates' failure to show their work.

Topics/Skills in which candidates showed strengths:

- Candidates showed that they are very skilled in the use of the calculator to perform basic operations.

- Candidates were able to substitute a value into a simple algebraic expression and solve a simple linear equation.

- In the graph question the candidates got the table correct and had no problem drawing a correct graph.

- Candidates displayed proficiency in interpreting Venn diagrams and getting the mode.

Areas of weakness in candidates' answering

- Some candidates did not engage successfully with tasks requiring abstract reasoning (algebra), statistical analysis, manipulation of fractions: manipulation of percentages, manipulation of the metric system, Pythagoras' Theorem, and set theory. Many of these candidates had difficulty with geometric constructions, which require relative precision, relative accuracy and dexterity.

- Candidates did not always display their work. This may have resulted from over reliance on the calculator and from lack of practice.

- Most candidates knew that percentages had something to do with 100 but many were not skilled in this topic.

- Geometry caused significant problems for most candidates and many just produced free-hand diagrams in Q.2(c) andQ.3(b).

- Many candidates failed to get the volume of a cylinder properly, even when given the formula. Ability to get the correct radius and adding values were the main problems.

- Calculating angles for the pie chart caused problems and many did not know what a pie chart was and drew a bar- chart or trend graph.

- Converting units of measurement posed problems for some candidates.

2.5 Recommendations to Teachers and Students

Teachers

- Teachers should ensure that the syllabus is covered fully.
- Teachers should use methodologies suggested in the revised Junior Certificate, as this allows students to have a more hands on approach in developing a deeper understanding of mathematics.
- The *Guidelines for Teachers* has many examples of methodologies and the Mathematics support Service offers much practical help and advice.
- Teachers should encourage the understanding of concepts, rather than relying on "rote" learning.
- Teachers should stress the significance of the 'Pen-in-Hand (✍)' symbol.
- Teachers should encourage estimation as a routine part of numerical work.
- In class work and homework teachers should encourage students to show their work.
- Teachers should encourage discussion and investigation of all the mathematics involved in solving a problem.

Students

- Students should be encouraged to attempt all sections of every question.
- More practice at using geometric equipment is required to improve accuracy.
- Students should have their geometrical instruments with them for the examination. It is very likely that they will be required for certain parts of questions.
- Students need to show their calculations, where required.
- If the 'Pen-in-Hand (✍)' symbol is present, students should show work to get full marks, even if your answer is correct.
- If there is no 'Pen-in-Hand (✍)' symbol present, students should show their work anyway. Then, even if you make a mistake, it is still possible to get some marks.
- Students should have a calculator with them.
- Students should read the questions carefully.
- Students should try to understand all of the concepts and steps involved in solving problems and if there are matters of which they are not clear, ask their teacher.
- Students should practise doing questions from past examination papers.

3. ORDINARY LEVEL

3.1 Introduction

The Examination consists of two papers, each comprising six questions.

All questions must be attempted on each paper to obtain full marks. Each question carries 50 marks.

The 'Pen-in-Hand (✍)'symbol indicates that supporting work must be shown for full marks.

The duration of each paper is 2 hours.

In each case, the question paper is the answer book.

Paper 1

- The majority of candidates answered all questions.
- The overall standard of answering was good. Grade C or higher was achieved by 78% of candidates, while 7% achieved less than a D grade.
- Less able candidates demonstrated poor algebra skills.
- Candidates achieving less than a D grade did not attempt many parts of the questions asked.
- Less able candidates demonstrated poor organisational and communication skills in the presentation of work.

Paper 2

- The standard of answering this year was quite good.
- A 76·6 combined A, B, C rate and a rate of 8% for those who achieved less than D was helped in no small measure by the design of Question 4 and also of Question 6, both of which were very candidate friendly.

3.2 Performance of Candidates

2006 Total Number of Candidates: 26820							
Grade	A	B	C	D	E	F	NG
Percentage of Candidates	13·3	36·7	27·9	16·1	4·4	1·5	0·1

The table below shows the individual percentage returns for both Paper 1 and Paper 2.

2006	A	B	C	D	E	F	NG
Paper 1 (% results)	19·1	34·2	24·9	14·8	5·6	1·3	0·0
Paper 2 (% results)	12·4	34·7	29·5	15·4	5·8	1·9	0·2

The average mark per question and its topic is shown in the table below for each paper.

Paper 1:

Question	Average Mark	Topic
1	40·4	Sets
2	37·0	Applied Arithmetic; Number Systems
3	40·3	Applied Arithmetic
4	33·9	Algebra
5	25·3	Algebra
6	29·5	Functions and graphs

Paper 2:

Question	Average Mark	Topic
1	35·4	Applied Arithmetic and Measure
2	35·1	Measure
3	39·9	Sets
4	29·2	Geometry
5	35·5	Coordinate Geometry
6	30·4	Trigonometry

3.3 Analysis of Candidate Performance

Paper 1:

Question 1 **Average mark: 40·4**

Question 1 was a popular question, attempted by most candidates.
It was one of the few questions on the paper answered correctly by virtually all candidates

(a) The standard of answering was excellent. Most candidates filled the elements of *A* and *B* correctly**.** Common mistakes were: the omission of element "*e*"; putting the same element into both sets.
The section was attempted by all candidates.

(b) This section was well answered except for cardinal number symbol '#' which many candidates didn't understand. Quite a number of candidates didn't understand the P' symbol. In general the lack of understanding of symbols in part (b) caused problems for some candidates.

(i) The standard of answering was very good.
The most common approach was to list some elements of $Q \cup R$ or $Q \cap R$.Common mistakes were: giving {7, 10} or {6, 8, 9, 10} as the answer. The question was attempted by 100% of candidates.

(ii) The standard of answering was very good. Common mistakes were: misreading; giving {1, 5, 8} or {4, 6, 9, 10} or {1}; sometimes inclusion of elements 2 or 3. This section was attempted by all candidates.

(iii) The standard of answering was good**.**
Common mistakes were: {1, 4, 5, 7} instead of P'; {2, 3} missing.
The section was attempted by all.

(iv) The standard of answering in this section was poor.
Most common incorrect approaches were: {1, 7, 8, 10 }; {2, 3}
and #R $\leq$ 10.
The question was attempted by 100% of candidates.

(c) This section was not well answered by some candidates. Some candidates were unable to manipulate the numbers given. It was interesting to note that a significant number who could not represent the information in a Venn diagram in part (i), were still able to answer the other parts of the question correctly - possibly because they were given in non-mathematical language - e.g. ‘how many students do not own a mobile phone?’

(i) The standard of answering was fair
Common mistakes were: filling in 21, 7 and 12 directly into the diagram, and working out 14, 7 and 5 correctly but omitting 4.
The question was attempted by 100% of candidates.

(ii) This section was answered very well.
Mistakes were rare and all candidates attempted this part.

(iii) The standard of answering in this part was excellent.
A common mistake was: the use of some relevant number.
This part was attempted by all.

(iv) The standard of answering was very good.
An observed error involved the incorrect use of some given numbers.
This part was attempted by all candidates.

Question 2 Average mark: 37·0

This was a popular question attempted by most candidates.

(a) The standard of answering was good.
Common mistakes were: dividing by 8 or 9, or dividing by 2.
The question was attempted by all candidates.

(b) **(i)** The standard of answering was quite good.
A common error that occurred was**:** multiplying by 1·21
This section was attempted by all candidates.

(ii) There was a very good standard of answering in this part.
A common mistake was: not rounding off sufficiently.
The section was attempted by all candidates.

(iii) The standard of answering was good.
A common error was: breaking order resulting in 7·868.
The section was attempted by all candidates.

(c) **(i)** The standard of answering was fairly good.
There was a lot of evidence of guesswork here in the cases of those who got it wrong.
Common mistakes were: multiplying 16 by 3 = 48 or $(4)^3$ = 64 or $4^4 = 256$
The section was attempted by all candidates.

(ii) The standard of answering in this section was very poor.
The most common mistake was: candidates couldn't write the number using scientific notation.
The question was attempted by all candidates.

(iii) The standard of answering was very good.
Common errors were: mishandling either fraction or square root; adding before multiplying. Some candidates rounded off incorrectly at the end or failed to round off. This section was attempted by all.

Question 3 Average mark: 40·3

This was a popular question, which was attempted by most candidates (approx 99%).

(a) The standard of answering was excellent.
A common error was: treating 65 cent as €65**.**
Numerical errors or multiplication errors also occurred.

(b) **(i)** Some candidates had difficulties working with percentages even with a calculator % button. Other candidates failed to add to finish, which suggests they may have been somewhat careless in their reading of the question.
The standard of answering was good.
Common mistakes were: no addition of VAT; mishandling 21%.
The section was attempted by 99% of candidates.

(ii) The standard of answering was very good.
Common mistakes were: decimal errors; no addition of interest; mishandling 2·6%.
The question was attempted by 99% of candidates.

(c) This section was not well answered in general. Some candidates showed little intuitive understanding of how tax is calculated and deducted.
Some added tax to get the total take home pay, displaying an inability to relate their learning to a practical real life situation.
As in the previous question, working out the percentages caused difficulties but also candidates showed little common sense in breaking up the total amount into 2 bundles to apply the different tax rates.
Some guesswork was evident here – i.e. almost any number or combination of numbers were used except the correct ones. In particular, in part (iv), a significant number of candidates completely left out the tax credit or mishandled it.
Another common mistake was to work out the tax correctly but not subtracting it from the gross to get the net take home pay.

(c) **(i)** The standard of answering was very good.
A common mistake was the mishandling of 20%.
This section was attempted by 99% of candidates.

(ii) The standard of answering was good.
Common mistakes were: using 730, 440, 440-88 or some other figure instead of 290.
The question was attempted by 99% of the candidates.

(iii) The standard of answering was very good.
A common error was: including the tax credit.
The question was attempted by 99% of candidates.

(iv) The standard of answering was poor.
Common mistakes were: misuse or no use of tax credit.
The question was attempted by 99% of candidates.

Question 4 Average mark: 33·9

A popular question attempted by most candidates.

(a) **(i)** The standard of answering in this part was very good.
Common mistakes were: treating 3(2) as 5 or 32.
The question was attempted by 99% of candidates.

(ii) The standard of answering was very good.
Common mistakes were: treating (2)(5) as 7 or 25.
The question was attempted by 99% of candidates.

(b) (**i)** & **(ii)** These sections were well answered by a significant number, but many showed little appreciation of the rules of algebra – i.e. adding numbers to variables and showing little respect for signs.
Some candidates made transposition errors and distribution errors, in particular when the multiplication involved negative quantities.
In addition, some candidates were unable to finish off and get a value for x.

(i) The standard of answering was very good.
Common mistakes were: transposition errors; distribution errors; combining "x" to "numbers".
The question was attempted by 99% of candidates.

(ii) The standard of answering was good.
Common mistakes were: combining unlike terms leading to oversimplification and transposition errors.
The section was attempted by 99% of candidates.

(c) **(i)** The standard of answering was very good.
A common error was: omitting coefficients.
The section was attempted by 99% of candidates.

(ii) This section was poorly answered. Many made basic errors, such as multiplying across by a number for each equation.
Many candidates stopped after getting the first variable. A significant number attempted to find the answers by trial and error.
A common mistake was: failure to multiply an entire equation by a constant.
The section was attempted by 99% of candidates.

(iii) The standard of answering in this section was poor.
Common mistakes were: using only one equation;
failure to conclude, if results were unequal.
The section was attempted by 95% of candidates.

Question 5 Average mark: 25·3

Question 5 was the least popular question on the paper.

(a) The standard of answering was good.
Common mistakes were: distribution error; combining unlike terms.
The question was attempted by 98% of candidates.

(b) This section was poorly answered. Many candidates showed poor understanding of the concept of factorisation or poor recognition of the different types involved. Most common mistakes included: rearranging letters at random with no obvious purpose; adding 'squares' onto them.

(b) (i) The standard of answering was very poor.
The most common mistake was: writing y^2 as a factor.
The question was attempted by 98% of candidates.

(ii) The standard of answering was quite good.
The most common mistake was: incorrect common factors.
The question was attempted by 98% of candidates.

(iii) The standard of answering was poor.
The most common mistakes were: use of 18 or 1296 in the answer.
The question was attempted by 80% of candidates.

(iv) The standard of answering was good.
The most common mistakes were: writing $4a^2$ as $16a$ and adding $8a$.
The question was attempted by 98% of candidates.

(c) (i) The standard of answering in this section was very poor.
Most common mistakes were: equating $5x$ or $4x$ or similar with 14; finding factors and stopping.
The question was attempted by 80% of candidates.

(ii) The standard of answering was poor.
Common mistakes were: distribution error; omission of denominator; failing to tidy up at the end.
The question was attempted by 95% of candidates.

(iii) The standard of answering was poor.
Most common mistake was: substituting into one expression only.
The question was attempted by 95% of candidates.

Question 6 Average mark: 29·5

Question six was attempted by most candidates.

(a) **(i)** The standard of answering was quite good.
Common mistakes were: multiplying expression by 4; sign errors and numerical errors.
The question was attempted by 97% of the candidates.

(ii) The standard of answering was quite good.
Common mistakes were: multiplying expression by -5; sign errors and numerical errors.
The question was attempted by 97% of the candidates.

(b) TABLE

The standard of answering was good.
Common mistakes were: sign errors; $-x^2$ treated as x^2; $4x$ treated as 4; 1 treated as x; and $-(-1)^2 = 1$ was very common.
The question was attempted by 97% of the candidates.
There was little evidence of the points being obtained from the newer calculator directly. There also seemed to be a fairly equal divide between those using the "table" method and the "function" method.

GRAPH

Many of those who did badly in this question tended to be careless about scale or careless plotting points and lost marks because of this.
Among the less able candidates, problems plotting points with negative co-ordinates in particular were common.
The standard of answering was poor.
Common mistakes were: scale errors; plotting errors and axis errors.
The question was attempted by 85% of the candidates.

(i) The standard of answering was very poor.
This part was rarely attempted.
The question was attempted by 20% of candidates.

(ii) The standard of answering was good.
A common error was: only indicating 3·5 on the axis.
The question was attempted by 75% of candidates.

Paper 2:

Question 1 — Average mark: 35·4

(a) This section was generally very well answered. The most common mistake was in conversion from m to km.

(b) **(i)** This section was very well answered. Common mistakes involved: giving the correct answer without work; finding the perimeter.

(ii) This section was well answered. A common error involved: omitting the $\frac{1}{2}$.

(iii) This section was poorly attempted. Only the A and B candidates were able to do justice to this part.

(c) **(i)** This section was poorly answered. The main problem for candidates was the conversion of hours to minutes. Many candidates miscalculated $\frac{50}{60}$ = 83 minutes.

(ii) This section was very well answered by most candidates.

(iii) This section was poorly answered, with very few candidates calculating the correct average speed.

Question 2 — Average mark: 35·1

(a) This section was well answered. The most common mistake involved: $9 \times 12 = 108$, i.e. multiplying the length of one side of the tile by the number of tiles.

(b) **(i)** This section was well answered by most candidates. $3{\cdot}14 \times 5$ without formula was very common and also the use of $2\pi r$.

(ii) This proved difficult for most candidates with few getting the three steps correct. Most got the correct area of the rectangle but encountered problems getting the area of the two discs.

(c) **(i)** The volume of the cylinder was well calculated with work shown.

(ii) This section was poorly answered with the attempt mark regularly awarded.

(iii) Candidates found this part difficult and it was poorly answered.

Question 3 — Average mark: 39·9

This was the best answered question in 2006.

(a) This was the best answered section of the paper with the vast majority of candidates achieving full marks.

(b) **(i)** This section was very well answered. Marks were lost by some candidates giving the correct answer without work or by not treating the total angle at the centre of the circle as 360°.

(ii) This section was answered reasonably well. A common mistake involved the use of an incorrect ratio.

(iii) This section was not as well answered as part (ii), but most candidates achieved the attempt mark for stating a relevant angle.

(c) **(i)** This section was extremely well answered, earning full marks for most candidates.

(ii) This part was answered well. A common error involved reversing of the variable and frequency.

(iii) This section was not well answered with $\frac{150}{5} = 30$ offered as the answer by quite a few candidates. The attempt mark dominated this section.

Question 4 — Average mark: 29·2

Geometry was not as well answered as the other questions on the paper. However, most of the question this year was "candidate friendly" and a great effort was made in answering most parts by the candidates.

(a) This section was very well answered.

(b) **(i)** There was a good standard of answering in this part. Common mistakes were: $12 \times 12 = 144$ or 12 on its own.
Reasons given for candidates' area of parallelogram varied, but very few gave the specific reason, i.e. that the diagonal bisected the area.

(ii) This section was well answered. A common mistake here was an answer of 2·5.

(iii) This section was poorly answered by many candidates. The majority of candidates were unable to bisect the given angle. The most common attempt involved joining c to b with no further work.

(c) **(i)** This section was poorly answered. Most wrote 90° or named an angle equal in measure to the given angle.

(ii) Most had an idea that congruent meant "equal in all respects", but did not give a clear reason as to why the triangles were congruent. The attempt mark usually applied here.

(iii) The majority of candidates knew the theorem of Pythagoras but were unable to form the correct equation. The attempt mark prevailed, usually for finding the length of the diameter.

Question 5 — Average mark: 35·5

(a) There was a very good standard of answering in this part. Some candidates had the order of the couple incorrect.

(b) **(i)** The mid point formula was very well used. Some errors arose due to incorrect substitution or errors in manipulation of signs.

(ii) This section was very well answered with similar errors to part (i).

(iii) There was a good standard of answering in this section. The most common error was the omission of or an incorrect value for m, the slope.

(c) **(i)** Only the A and B candidates could handle this part with any degree of success.
Many candidates took $7(0) = 7$, while others had mistakes in transposition.

(ii) Very few candidates knew what to do for this part and, as such, often left it blank. The concept of axial symmetry was not well understood.

Question 6 Average mark: 30·4

Higher marks than usual were achieved in this question which was very "candidate friendly".

(a) **(i)** This section was well answered by those who attempted it, with the usual confusion as to the correct side to choose.

(a) **(ii)** There was a good standard of answering. The most common error involved inverted ratio.

(b) **(i)** This section showed a good quality of answering. Several candidates proceeded to do further calculations in the box. Possibly they thought it was too easy to be asked just the Cos 60° and were looking for a non-existent complication. Some candidates had their calculators in the wrong mode.

(ii) This section was poorly answered. Candidates were unable to relate this to part (i) and, if they did, they still had to contend with transposition problems.

(c) **(i)** This section was well answered by the better candidates. An error here usually involved the three angles in a triangle not adding up to 180°.

(ii) This section was very poorly answered, if attempted at all.

3.4 Conclusions

Paper 1

- The format of the paper ensured that the majority of candidates remained engaged with the examination tasks until they had attempted the majority of questions presented to them.

- Supports and directions given to the candidates by way of clear 'Pen-in-Hand' symbols, adequate size work boxes, correct font size, and the use of keywords resulted in a candidate friendly paper being available to the candidates.

- The disengagement of some candidates from multiple subsections of questions involving concepts such as algebra, manipulation of fractions, and the drawing of graphs was a major factor in determining their final grade.

Topics/Skills in which candidates showed strengths:

- The candidates exhibited a good level of competency when dealing with Sets, Money, Ratios, Currency Exchange and, to a lesser extent, the Quadratic Graph.

- Most candidates made good use of their calculators.

- Most candidates scored highly on multiple-part questions regardless of initial errors, thus showing some understanding of the material involved.

Areas of weakness in candidates answering.

- The algebra questions were poorly answered. The concepts of factorisation, multiplication, and solving equations are poorly understood by some candidates.

- Scientific notation and the concept of verification were poorly understood by most candidates.

- Mishandling the percentage, decimal errors and rounding to the nearest whole number or to two places of decimals caused problems for some candidates.

- The Functions & Graphs question produced numerous graphing errors. Candidates inability to recognise an incorrect graph here suggests a poor understanding of the topic.

- The concept of gross tax in Q3(c) was poorly understood.

Paper 2

- There was an improvement in the answering of the geometry and trigonometry questions in 2006. The diagrams accompanying these questions were very well designed and provided good links to the questions.

- The diagrams in Question 2 were also very well laid out and would have been of great benefit to the average candidate.

Topics/skills in which candidates showed strengths

The main areas of strength were:

- Statistics.
- PIE Chart Analysis.
- Calculation of area i.e. rectangle and triangle.
- Co-ordinate geometry, particularly using the given formulae.
- Use of calculator.

Areas of weakness in candidates' answering

- Converting metres to kilometres.
- Conversion of hours to minutes.
- Time/distance/speed formulae and their application.
- Knowledge of axial symmetry.
- Application of Pythagoras' Theorem.
- Finding the mean from a frequency table.
- Bisecting an angle.
- Establishing congruence.
- Understanding mathematical notation, e.g. $|\angle cad|$ means measure of angle *cad*.
- Candidates continue to lose marks by not showing supporting work i.e. ignoring the 'Pen-in-Hand' Symbol.

3.5 Recommendations to Teachers and Students

Teachers

- Teachers should ensure that the syllabus is covered fully.
- Teachers should use methodologies suggested in the revised Junior Certificate Guidelines, as this allows students to have a more hands on approach to develop a deeper understanding.
- The *Guidelines for Teachers* has many examples of methodologies and the Mathematics support Service offers much practical help and advice.
- Teachers should encourage the understanding of concepts, rather than relying on "rote" learning.
- Teachers should stress the significance of the 'Pen-in-Hand (✍)' symbol.
- Teachers should encourage estimation as a routine part of numerical work.
- In class work and homework, teachers should encourage students to show their work.
- Teachers should encourage discussion and investigation of all the mathematics in solving a problem.

Students

- Students should show all work as clearly as possible. This is essential where the 'Pen-in-Hand **(✍)**' symbol appears on the paper.
- Students should be encouraged to relate what they are learning to examples from everyday life e.g. rounding off numbers can be used to calculate the approximate change you get in a shop.
- Students should be encouraged to read questions fully and carefully.
- Students should attempt all questions and parts thereof if at all possible.
- The use of a pencil as a primary writing instrument in examinations is to be discouraged.
- Students should exercise care when transferring numbers from the calculator to the exam paper. Carelessness here can prove costly in terms of marks lost.
- Students should round off answers when required to do so.

- Students should keep their calculator in DEG mode.
- Students should write down relevant formulae and attempt some substitution.
- Students should practise the various constructions on the course.
- Students should study the reasons why triangles may be congruent.
- Students should read questions carefully and look out for links between parts.
- Students should show all work involved in working out answers.
- Where a calculator is used, students should try to include intermediary steps.
- Students should show supporting work where the ‘Pen-in-Hand’ symbol is relevant.

4. HIGHER LEVEL

4.1 Introduction

The Examination consists of two papers, each comprising six questions.

All questions must be attempted on each paper to obtain full marks.

The 'Pen-in-Hand (✍)'symbol indicates that supporting work must be shown for full marks.

Each question carries 50 marks.

The duration of each paper is 2 hours and 30 minutes.

- The vast majority of assistant examiners expressed the view that the paper enabled the higher ability candidate to achieve high marks, and provided the less able candidates with every opportunity to achieve 40%.

- Those not achieving D grade were generally significantly short of it.

- The view was expressed that the papers encouraged a positive view of mathematics.

- Examiners continue, as in previous years, to be concerned about knowledge and understanding of Trigonometry.

4.2 Performance of Candidates

2006 Total Number of Candidates: 24204							
Grade	**A**	**B**	**C**	**D**	**E**	**F**	**NG**
Percentage of Candidates	18·0	32·0	28·7	17·2	3·4	0·6	0·0

The table below shows the individual percentage returns for both Paper 1 and Paper 2.

2006	**A**	**B**	**C**	**D**	**E**	**F**	**NG**
Paper 1 (% results)	18·9	33·9	29·7	13·4	3·4	0·6	0·0
Paper 2 (% results)	19·1	29·6	25·3	18·2	6·5	1·2	0·1

Paper 1

Question	**Average Mark**	**Topic**
1	40·9	Applied Arithmetic; Number systems
2	33·5	Applied Arithmetic; Sets
3	34·6	Number Systems; Algebra
4	27·1	Algebra
5	40·2	Algebra ; Functions and Graphs
6	32·9	Algebra; Functions

Paper 2

Question	**Average Mark**	**Topic**
1	37·5	Measure
2	33·2	Coordinate geometry; Geometry
3	40·5	Geometry
4	30·5	Geometry
5	29·3	Trigonometry
6	38·4	Statistics

4.3 Analysis of Candidate Performance

Paper 1:

Question 1 **Average mark: 40·9**

This was the best answered question on the paper. Many candidates achieved full marks.
The question drew heavily on realistic mathematics and part (c) (ii) challenged the most able candidates.

(a) This was a popular question, which candidates handled well. It was correctly answered by all except the less able candidates. Finding the increase and expressing it as a percentage of the original price was the most common approach.

(b) **(i)** The Speed/Distance/Time relationships were well known. Many scored full marks. A common error was to take 6h and 45 min as 6·45h. Some, a small number, found the mean of the two average speeds rather than the difference. A small number of candidates created extra work by working in other units e.g. m/min.

(ii) This was a well answered question. Many approached it by using a table. This was helpful. Only the less able candidates made errors in the use of tax credits.

(c) **(i)** While many achieved full marks here, there was a significant number who made errors in precedence in the estimate.
For example $18 – 4 \times 4$ was taken as $(18 - 4) \times 4$ leading to $\frac{8}{56}$ which then became 7.
In the Evaluation section candidates showed their work. The only issue was early rounding off.

(ii) This section was the most challenging part of this question, with many candidates subtracting 5% for each year. A number of candidates failed to understand the significance of compounding interest and subtracted a simple 10%.

Question 2 — Average mark: 33·5

This was one of the more testing questions as reflected in its average mark. It incorporated a high level of realistic mathematics in part (c)

(a) This was a very well answered question.

(b) **(i)** This section was poorly answered. Typical marks were 3 or 4.
A possible cause was the fact that the topic, Venn diagram of 3 sets, may not have been revised since second year. It also incorporated algebra.
There were two types of common error: failing to subtract inner area cardinal values, x and 4, from the outer areas e.g. $\#(F \cap S) \setminus I$ given as 12; likewise $\#(I \cap S) \setminus F$ given as 8; cardinal numbers omitted from diagram, 70 and/or $2x$

(ii) This proved difficult for many candidates. Often an oversimplified approach was taken with an equation formed without use of the $\#U = 70$ and /or $\#(U \setminus F \cup S \cup I) = 2x$. Candidates had difficulty in forming the equation. Terms were often omitted.

(c) A very relevant/realistic question involving currency rates. Candidates frequently used figures incorrectly without any explanation.

(i) This section was well answered. The principal error was: early rounding off, giving £3·60. Less able candidates multiplied rather than divided for currency conversion.

(ii) This section was poorly answered.
The meaning of "*The selling price in sterling remains the same*" was not understood.
Candidates' work was often illogical comprising manipulating figures from part (i).
Common errors included: working with/mixing two currencies;
% profit not based on cost price; using the selling price from part (i) as the cost price; no new profit found.
This part of the question offered a good challenge to the more able candidates.

Question 3 Average mark: 34·6

The content and layout triggered a range of responses.
Part (b) was considered easy, not only because of its content but also its presentation/layout where the two required equations were easily formed.
Part (c) was a very suitable question for this level.

(a) (i) and (ii) This section was not well answered, indicating poor knowledge of indices. Candidates did not use calculators. There were a number who gave $\frac{64\times 3}{2}$ as an answer.

(b) This question was answered correctly by almost every candidate.

(c) This questions was almost identical to Q 4(c) 2005. However it was very poorly answered.

(i) The principal errors in this part were: treating as an equation and multiplying across by the lowest common multiple, hence the denominator was dropped; sign errors in multiplying out the numerator often leading to zero which candidates changed to force an answer.

(ii) Candidates generally restarted the question and handled the equation better than the expression. However, a number of errors frequently occurred: the right hand side was multiplied out incorrectly producing a linear equation or a more complicated quadratic equation; few recognised the difference of two squares; distribution and sign errors when multiplying; only giving one solution.
While the solutions to $x^2 = 4$ were easy to find, many candidates failed to recognise them and used the formula.

Question 4 — Average mark: 27·1

This was the lowest scoring question on the paper. It required a good knowledge of algebra and surds. Part b(iii) incorporated a good realistic element into the question.

(a) This was the most poorly answered question on the paper, showing that candidates' knowledge of removal of brackets is very poor. Often the work was seriously incorrect.
The following is a list of common errors:
Multiply the inner bracket by 3 and/or outer bracket by 2x generating answers containing x^2; brackets seemed to trigger a reaction of multiplying; removing brackets without reference to minus sign outside; setting up an equation - confusing an expression and an equation

(b) **(i)** This was a good testing question. Most candidates knew the quadratic formula and how to apply it. Difficulties arose in working with surds and getting the answer into the required form. Errors generally occurred after the expression had reached $x = \frac{4 \pm \sqrt{48}}{2}$.
They included: going directly to decimals, therefore no work with surds; incorrect cancelling such as $2 \pm \sqrt{24}$ or $4 \pm \frac{\sqrt{48}}{2}$.
Few candidates were awarded full marks.

(ii) This question tested knowledge of the difference of two squares and the section was well answered. Most common incorrect answer was: $(9x\text{-}16)\ (9x\text{+}16)$.

(iii) There was a reasonable level of answering here. Both factorising and division methods were used. Most errors occurred in the latter, in particular change of signs when subtracting.

(c) This question is similar in format to that set for the past three years. Assistant Examiners, who marked in previous years, felt candidates are getting better at this type of problem. Candidates were helped by its clear layout.

(i) Generally, this section was well answered. Errors included:
$\frac{x}{540}$; $540 - x$.

(ii) At this point candidates started to experience more difficulties as the question required in-depth reading.
Common errors were:

$$\frac{300}{x};\ \frac{300}{x} - 1;\ \ \frac{540}{x \pm 1}$$

(iii) At this step candidates made more mistakes. Often minus, - , was used in the equations, suggesting they were following the method of previous years.

(iv) Many candidates made errors in solving the equation. Errors included: generating a linear equation; failing to find factors of the quadratic equation; failing to find 'the number of days' from x.

Question 5 Average mark: 40·2

This was one of the best answered questions. A considerable number of candidates achieved full marks. The question incorporated a high level of realistic mathematics.

(a) There were varying levels of success with this question. Many candidates made it more complicated by accumulating the x leading to answers such as $6x$ -12. A number of candidates failed to simplify the final expression $x + 6$ -12.

(b) Candidates did very well in this part of the question. The table was correct and few errors were made in graphing the function. Some, however, gave the graph a ' flat top '. Candidates might give more time to devising scales. Difficulties arose in part (c) when the scale on the x-axis was very small.

(c) While many candidates achieved full marks, a number of errors were common to all parts. These were: failing to indicate answers on the graph; misreading the y-axis e.g. (c) (i), 61 read as 60·1. Clearly a decimal error.

(iii) This section was well answered. It is likely that the realistic nature of the problem helped candidates.

Question 6 — Average mark: 32·9

This was a relatively low scoring question.

(a) This question evoked a wide variation in standard of answering. All the typical transposition errors were encountered. The fact that a significant number of candidates scored 50 marks for this question suggests better candidates are able to manipulate expressions

(b) **(i)** A testing factor question because of the minus signs. While the principle was understood many candidates had difficulties extracting the common factor correctly and often forced an answer
e.g. $l(2 - k) + m(k - 2)$ became $(2 - k)(l + m)$

(iii) Generally, this section was well answered. Those candidates who used the formula often failed to form factors from roots.

(iii) This was a relatively easy factorising question. Many candidates answered it correctly. The common error was to treat as the difference of two squares.

(c) **(i)** This part was correctly answered by most candidates. The only error was in sign of $g(5) = 1-5^2$

(ii) This section was poorly answered, indicating knowledge of functions and function notation needs attention. Even candidates who successfully found $-3x - 2$ changed it to $3x + 2$ for part (iii).

(iii) This section was attempted by most candidates who were helped by the marking scheme accepting work from previous parts. As noted at (ii), candidates changed sign of answer.

Paper 2:

Question 1 — Average mark: 37·5

(a) This section was well answered, with candidates choosing the correct formula and correct radius with the rarest of exceptions. The only difficulty, which occurred right throughout the question, was the variety of values for π (both in decimal and fraction form). Common errors were: use of volume of cone; radius = 9; answer not rounded off.

(b) **(i)** The general method used was 96 divided by 4, and answer squared. This was used by at least 90% of candidates.
Common errors were: 98 divided by 2 and continues; $\sqrt{96}$ for side and continues; correct answer without work.

(ii) Generally the correct formula was used, although a small number found the total surface area of the cylinder. There was quite a lot of confusion with units, particularly square units.
Common errors were: radius = 75cm; leaving answer in cm^2; failure to convert cm^2 to m^2 – usually divided cm^2 by 10 or 100; not rounding off.

(iii) This section was poorly attempted by one third of candidates.
Common errors were : units of measure not corresponding; fraction inverted, before attempting percentage; division by 100 for percentage; multiplication of area of lawn by 9.

(c) This was a very well attempted section with candidates choosing the correct formula, and inserting as required. Errors were unusual. When errors occurred they were: use of 32π; failure to deal with $4\pi/45$ correctly; statement beginning with $16\pi = \frac{4}{45}\pi$ and attempting to continue.

Question 2 — Average mark: 33·2

(a) The formula was correct in almost all cases, and values were inserted appropriately. Errors were mostly with signs. Common errors included: mixing up *x* and *y* values; simplifying (-2- -6) and similar.

(b) **(i)** The midpoint formula was used correctly and the section was fully answered correctly in practically all cases.
Errors (Rare) were: Incorrect sign in formula; mixing x and y values; leaving answer in fraction form.

(ii) The slope formula was known by practically all candidates.
A common error was: sign in either formula or with values.

(iii) At least 50% incurred blunder(s) here, with either slope or point on perpendicular bisector. Of those who were unsuccessful, more than half used $\frac{1}{2}$ as the slope, while a similar number did not use the midpoint but chose either *p* or *r*. In effect a significant number incurred both errors.

(iv) This section was generally well done. Some of the values proved awkward, but the methodology was consistently of a high standard. Common errors were: simplifying the equation from (iii);signs; cross multiplication; value of one variable only found.

(c) The theorem was rarely totally correct, with many candidates incurring one or two penalties. Common errors were: step 5 of the marking scheme – incomplete with regard to the angles; step 4 of the marking scheme – reason for congruency; step 1 of the Marking Scheme – required to prove.

Question 3 — Average mark: 40·5

(a) A substantial number of candidates experienced difficulty with the calculation of the angles, although the better candidates (A and B grades) solved both correctly. Common errors were: $|\angle abc| = 115^0$; assuming $|\angle bac| = 90^0$ and continuing; sum of angles on a straight line $\neq 180^0$; correct and incorrect answers without any work shown.

(b) **(i)** The theorem was very well done with practically all candidates achieving full marks. A common error was: step 2 of the marking scheme – no reason stated for either set of statements.

(ii) For most candidates the theorem was not applied directly but the value for *x* was found using the sum of the angles of a triangle and angle on a straight line. Upwards of 15% of the candidates assumed that the angle at the apex was a right angle.

(c) **(i)** The construction of the triangle was well attempted, but a significant number of candidates presented imperfect work of varying degrees. Common errors were: no construction lines shown (common); triangles drawn outside the tolerance level; lengths correct, but not joined to form a triangle; two sides of relevant length with a right angle included.

(ii) The construction of the incircle proved very testing, with many candidates drawing 'manufactured' incircles with no construction lines, or 'false' bisectors included as justification.
Common errors were: perfect incircle in appearance, no construction lines and not relevant triangle; inaccurate bisectors of angles; incentres and radius which breached on one, two or all three sides of triangle.
The standard of answering of this subsection was far inferior to any other subsection of the paper.

Question 4 — Average mark: 30·5

(a) This section was very well answered, with practically all candidates presenting the correct answer. For quite a number no work was shown. The 'Pen-in-Hand' symbol was ignored by these candidates.
An error (rare) which appeared: $73^0 + |\angle adc| = 180^0$

(b) In the proof of Pythagoras theorem, both methods on the marking scheme were equally popular, but usually there were more errors with the square method. Common errors in the similar triangles method were: step 3 of the marking scheme – not giving reasons; step 2 of the marking scheme – construction incomplete; step 5 of the marking scheme – sign errors. Common errors in the alternative method were: not proving $|\angle 4| = 90^0$; not indicating each side of quadrilateral equal in length; not mentioning congruence of triangles; construction was very inaccurate. Candidates frequently lost 6 or 9 marks for this method as many attempted to present briefer versions with elements either missing altogether or incomplete.

(c) (i) Most candidates could find length of *km*, but the reasons offered by over 50% of candidates were very inaccurate.

(ii) The application of Pythagoras was well done with even the less able candidates applying it correctly. A handful of candidates inserted 30 rather than 15 in this section.

(iii) The area was correct for at least 75% of candidates. However, at least 10% of examiners reported that $|\angle kol|$ was assumed to be a right angle.

Question 5 — Average mark: 29·3

(a) This was the least well answered section (a) on the entire paper. In addition to at least one quarter of candidates presenting pilot diagrams, at least as many did not manage to retain a correct ratio or did not imply a right angle. Some, despite being instructed not to use a calculator or tables, insisted on finding an approximate angle.

(b) This section was very well attempted by the more able candidates but some of the most frequent errors were: not using two sides in the area formula; using the angle $21{\cdot}7^0$; angle at apex = 90^0, thus invalidating isosceles triangle.

(c) (i) This section was a straight forward application of the Sine Rule, although some candidates used it incorrectly by not finding $|\angle dfe|$. There were not many errors with the calculator in an incorrect mode. The overwhelming majority of candidates gained close to full marks here.

(ii) At least 25% of candidates found the area of the triangle by half the product of two sides × Sine of included angle first, and then equated this answer with $\frac{1}{2}.80.h$. These candidates answered the section very well indeed, while those using other methods continued to make errors. This section was not well done.

Question 6 — Average mark: 38·4

(a) The angles were generally correct and the pie-chart was properly drawn. Common errors were: no labelling of the angles or ratios on the pie chart; failure to connect ratios with the appropriate angle; sketch with angles not within tolerance; use of an angle other than 360°.

(b) (i) The frequency table was correct for practically all candidates. The only error by a few candidates was allocating the value of 60 incorrectly, but this was rare.

(ii) At least 75% answered this well, but the others made errors similar to candidates in previous years. Common errors were: division by 4; adding the frequencies; adding the mid-interval values; not finding the mid-interval value, but using either the upper or lower values of the intervals, and continuing with correct steps afterwards; not using table, but adding the values of all 25 candidates.

(c) (i) This section was generally answered well.

A rare error was: 'Cumulative cumulative' table

(ii) This section was not well answered by a large number of candidates. All presentations included a vertical axis, but the usual errors were with the base scale. Other errors were: trend graph with the base scale generally incorrect; attempts at Histogram or Bar Chart using the data from the cumulative table given on the paper; histogram or bar chart for (b)(i).

(iii) For those giving the correct answer a reason was rarely given. Many candidates gave answers (incorrect) which, without some indication of work, did not merit any marks.

4.4 Conclusions

Paper 1

The overall standard of answering was good ,with 82·5% of candidates achieving an A or B or C grade and 4·1% achieving less than a D grade.
These results are in keeping with results and from previous years.
Numbers sitting the examination increased in 2006.
Presentation of work was good, indicating that candidates clearly understood the role of the 'Pen-in-Hand (✍)' symbol**.**
Few candidates failed to attempt 6 questions.
Most candidates worked systematically through questions 1 to 6.

Topics/skills in which candidates showed strengths
It is evident from the discussion of individual questions that candidates are competent in the following:

- Work with percentages.
- Income Tax.
- Estimation.
- Speed problems.
- Simultaneous equations.
- Factors of the difference of two squares.
- Factors of Trinomial.
- Graphing quadratic function and interpreting same.
- Knowing and applying quadratic formula.

Areas of weakness in candidate performance

Areas of weakness are listed below. They identify the topics which clearly need attention in the classroom.

- Venn diagrams involving three sets.
- Working with surds.
- Working with indices.
- Simplifying and removing brackets from algebraic expressions, particularly expression containing minuses. Perhaps work with a calculator could help with this problem?
- Simplifying algebraic fractions.
- Function notation.
- Expressing complex information in mathematical language (Q 4(c)).
- The implications of rounding off too early – indicates a lack of understanding of how estimation works.
- Understanding mathematical language.
- Knowing the difference between an equation and an expression.

Layout of paper

The layout of the paper was good. Having one question per page ensured candidates did not miss parts. Presenting information in list form, for example question 2 (b), made it easy to read.
The use of *Clip Art* in the paper may have made it more appealing to candidates.

Paper 2

Topics/skills in which candidates showed strengths:

- All (a) parts, with the exception of 5(a) were answered very well.
- Choosing correct formula from mathematical tables and substituting appropriately was of a consistently high standard – area, volume (Q1), Sine Rule (Q5).
- Formulae for co-ordinate geometry of the line were for the most part correct, and correctly substituted in Q2(a), (b) (i), (b)(ii).
- Pie Chart and mean were very well answered. (Q6)
- The vast majority of scripts were presented in an orderly and clear fashion, with candidates far less inclined than previously not to show work.

Areas of weakness in candidates answers

- Manipulating units (Q1(b) (ii)converting cm^2 to m^2 or no mention of units.
- Lack of understanding of the term '*perpendicular bisector*' (Q2)- using incorrect slope and/or the point *p* or *r* in the equation.
- Construction of incircle (Q3 (c)) and construction of angle A in Q5 (a).
- Most candidates lost marks on theorems, particularly Q2(c) and Q4(b). It seems possible that candidates sacrifice the demonstration of the underpinning principles to writing proofs with minimal explanations. Rote learning may be a contributory factor here.
- Some candidates demonstrate a lack of comprehension of what constitutes a frequency table, and have difficulty distinguishing between bar chart, histogram, and trend graph (Q6). Similar issues arose last year with little to suggest an improvement in the standard of answering of this question this year.
- Trigonometry (Q5) continues to pose difficulty for all but the best candidates. There was some very poor answering for the construction of an angle (Q5(a)), while the area of the triangle caused difficulty in terms of appropriate angle and use of formula. Use of calculator in incorrect mode also featured but not as extensively as in previous years.
- Handling transpositions in algebraic type equations.
- Inability to divide by a fraction, (Q1(c)(ii)).

4.5 Recommendations to Teachers and Students

Teachers

- Teachers should ensure that the syllabus is covered fully to prepare students for topics that don't come up regularly.
- Teachers should use methodologies suggested in the revised Junior Certificate Guidelines, as this allows students to have a more hands on approach in developing a deeper understanding.
- The *Guidelines for Teachers* has many examples of methodologies and the Mathematics support Service offers much practical help and advice.
- Teachers should stress the significance of the 'pen-in-hand(✍)' symbol
- Teachers should discourage the use of pencil, and particularly erasing fluid in examinations.
- Teachers should ensure that the internet and suitable software is used when teaching geometry.
- Teachers should consult previous years' marking schemes. They are available at the State Examinations Commission's website: www.examinations.ie

Students

Before the examination

- Students should make sure to cover the full syllabus. Before the examination revise topics covered in First and Second Year.
- Students should practise questions from previous years' papers, especially those involving difficult/complex procedures, for example, equations containing algebraic fractions. However understand them, do not expect identical questions from year to year.
- Students should practise problem solving by doing unseen questions.
- Students should spend time learning how to use the calculator intelligently. Most calculators now contain very helpful functions, e.g. dealing with indices.
- Students should get into the habit of estimating, as a checking procedure, when using the calculator.
- Students should learn the order of precedence in the use of numerical operations.
- Students should practise working with negative numbers: the calculator may be a help in consolidating the laws which apply to their use.
- Students should identify and learn how to apply mathematical formulae e.g. $\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$.
- Students should learn how to check/verify answers.
- Students should become familiar with the meaning of mathematical language. For example in Q 6 (b) (i) $a \pm a\sqrt{b}$, where $a, b \in \mathbf{N}$.
- Students should not consider mathematics as a list of rules and procedures to be mastered, but should attempt to understand the processes behind them.

- Students should learn that presenting information in tabular form can help clarify certain topics, for example income tax and question 4 (c) type problems

During the examination

- Students should make sure to show all work even if there is no 'Pen-in-Hand (✍)' symbol.
- Students should attempt all questions and label them clearly.
- Students should try to make sure work is as neat and tidy as possible.
- Students should not use pencil in examinations.
- If a mistake occurs it is often better to restart the question. Put a single line through the previous attempt and begin afresh.
- Students should read all questions carefully, paying attention to units.
- When drawing a graph students should give consideration to the scales on the axes. Aim to produce a diagram which fills most of a page of graph paper. This will help answer questions from the graph.
- When using graphs to answer questions students should make sure to show / mark the source of your answer.
- When using a calculator, students should write the operation used e.g. $2{\cdot}34 \times 4{\cdot}56$. Estimate the answer to check the calculator has been used correctly.
- When rounding off, students should be aware of the implications of early rounding off.
- When dealing with Venn diagram students should make sure to work from the centre out taking account of intersecting values.
- Students should understand the meaning and importance of presenting answers in the required form.
- Students should verify answers. In equations substitute answers to check. After factorising students should check back by multiplying.
- If finished early students should not leave the examination centre without checking each question carefully for errors. Students should use all the time allowed to complete the paper.
- Candidates should show all necessary work.
- Candidates should state units of measurement and give answers in correct format.
- Students should use the value of π in the Mathematical tables or per calculator (three decimal places at least), unless otherwise asked.
- Students should understand that the statement "Find, in terms of π,.." means that no value for π should be inserted.
- Students should ensure that the calculator is in the correct mode.
- Students should ensure that theorems are comprehensively proven.
- Students should give more attention to the study of Statistics and Trigonometry.
- Students should leave the calculations in Trigonometry until the variable is isolated.