

# THE NATIONAL BENCHMARK TESTS: PREPARING YOUR LEARNERS FOR THE MATHEMATICS (MAT) TEST

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## INTRODUCTION

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This booklet will assist you in understanding what the NBT MAT test is about and tell you how to prepare your learners for it.

The National Benchmark Tests (NBTs) are a set of tests that measure an applicant's academic readiness for university. They complement and support, rather than replace or duplicate the National Senior Certificate.

A number of universities in South Africa use the NBTs to help interpret the National Senior Certificate (NSC) results. Universities use the NBT results in different ways:

- Some use them to help make decisions about an applicant's access to university. This means that the NBT results, in combination with the NSC results, are used to determine whether an applicant is ready for academic study.
- Some use them for placement within university. This means that the results are used to decide whether an applicant will need extra academic support after he/she has been admitted to university.
- Some use them to help develop curricula within their universities.

There are two tests: AQL, which is the Academic Literacy and Quantitative Literacy test, and MAT, which is the Mathematics test.

# 1. BACKGROUND AND PURPOSE OF THE MAT TESTS

## 1a. MATHEMATICS TEST ACHIEVEMENT LEVELS

To determine whether learners are able to make the transition between mathematics at secondary and tertiary level, the competencies that are required, but not necessarily made explicit, by Higher Education, need to be assessed.

Writers of the NBT are placed in one of three categories: Basic, Intermediate, and Proficient. For the Mathematics (MAT) tests, what does this mean? Have a look at the Achievement Levels below. You will see how much more is required for writers to move from the Basic category into the Intermediate category; similarly from Intermediate to Proficient. The table is based on the topics outlined under the heading “MAT TEST TOPICS”.

BASIC	INTERMEDIATE	PROFICIENT
Test writers performing at the <i>Basic</i> level will be able to apply simple concepts and use known procedures in familiar situations. In general they will cope with tasks that involve recall and reproduction of basic mathematical facts or performance of simple computations. Basic writers will typically be able to apply a single representation or technique to a single piece of information.	Test writers performing at the <i>Intermediate</i> level should be able to perform at the <i>Basic</i> level, and <u>in addition</u> be able to select strategies to solve problems and integrate skills, concepts and procedures. In general writers at this level will be able to manage mathematical tasks involving multiple steps requiring information processing and decision-making skills. Writers will typically be able to make connections between, and integrate, more than one piece of information, use various mathematical procedures and multiple representations in a sequence of steps. Test writers performing at the <i>Intermediate</i> level should be able to interpret an argument	NBT writers performing at the <i>Proficient</i> level should be able to perform at the <i>Intermediate</i> level, and <u>in addition</u> demonstrate in-depth knowledge of the relevant mathematical concepts and competence in multi-step procedures represented in the framework. <i>Proficient</i> level test writers should be able to demonstrate insight and integrate knowledge to solve complex problems. They should be able to make competent use of logical skills such as making conjectures and assessing the validity of deductions.

	and make logical deductions in the context of a wide variety of mathematical tasks.	
<p><b>Algebraic Processes:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>perform routine computations with real numbers</li> <li>perform simple algebraic manipulations</li> <li>identify simple number patterns (sequences)</li> <li>use variables that represent unknown quantities</li> <li>use expressions and equations that express simple relationships among unknown quantities</li> <li>recognise and use familiar formulae</li> <li>solve routine equations in one variable</li> <li>perform routine financial calculations</li> </ul>	<p><b>Algebraic Processes:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>estimate and calculate</li> <li>recognise and work with patterns (including geometric and arithmetic sequences)</li> <li>compare measures</li> <li>demonstrate understanding of the properties of inequality</li> <li>perform multi-step algebraic manipulations</li> <li>manipulate a variety of algebraic expressions, including those that involve surds, exponents and logarithms</li> <li>solve non-routine equations in one variable,</li> <li>solve systems of linear equations</li> <li>model situations (i.e. analyse given information, make an appropriate representation of the information) and solve problems using a variety of mathematical processes</li> </ul>	<p><b>Algebraic Processes:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>select and adapt appropriate formulae to solve non-routine problems</li> <li>solve and interpret systems of equations and inequalities</li> </ul>
<p><b>Functions and graphs:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>identify graphs of functions noted above</li> <li>solve routine problems involving functions expressed in a single form, whether verbally, algebraically or graphically</li> </ul>	<p><b>Functions and graphs:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>use and interpret the graphs noted in 3a</li> <li>solve non-routine problems involving functions expressed in multiple forms</li> <li>manage multiple representations of functions, and interpret the information</li> <li>demonstrate understanding of various characteristics of</li> </ul>	<p><b>Functions and graphs:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>interpret the relationship between functions and their inverses</li> <li>demonstrate understanding of the domain and range of a variety of functions, including trigonometric functions</li> <li>determine and interpret the meaning of gradients of certain functions and use the relationship between slope and tangent</li> </ul>

	<p>individual functions (including trigonometric functions) such as domain and range,</p> <ul style="list-style-type: none"> <li>interpret transformations and reflections of functions</li> </ul>	<ul style="list-style-type: none"> <li>apply the principles of differential calculus to functions, represented graphically or algebraically</li> </ul>
<p><b>Trigonometry:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>define specified trigonometric ratios in right triangle trigonometry</li> <li>recognise trigonometric graphs</li> <li>perform basic calculations with trigonometric ratios</li> <li>solve simple trigonometric equations</li> <li>recognise and use identities, compound angle formulae and reduction formulae</li> </ul>	<p><b>Trigonometry:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>apply trigonometric ratios to solve two-dimensional problems</li> <li>understand the properties of trigonometric graphs, including translations of these graphs</li> <li>apply the sine, cosine and area rules in simple contexts</li> <li>solve non-routine trigonometric equations</li> <li>apply trigonometric identities, reduction formulae and knowledge of special angles to solve problems</li> </ul>	<p><b>Trigonometry:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>interpret graphs of trigonometric functions, individually and in relation to one another</li> <li>apply trigonometric concepts to solve non-routine problems in two- and three-dimensional contexts</li> </ul>
<p><b>Spatial perception:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>identify properties of two- and three-dimensional figures, such as angle or symmetry properties</li> <li>perform routine calculations involving perimeter, area and volume</li> <li>use relevant analytic geometry formulae</li> <li>recognise the relevant Circle Geometry axioms and theorems</li> </ul>	<p><b>Spatial perception:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>recognise properties of geometric figures in two and three dimensions and determine relationships between different objects</li> <li>perform non-routine calculations involving area and volume</li> <li>apply Circle Geometry axioms and theorems to solving typical geometry problems</li> </ul>	<p><b>Spatial perception:</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>use properties of various geometric figures and objects, and relationships between them, to solve problems relating to area and volume of composite figures and objects</li> <li>to solve more complex geometric problems requiring the application of axioms and theorems of Circle Geometry</li> </ul>
<p><b>Data handling and Probability</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>identify and use measures of central tendency</li> <li>recognise statistical representations of information</li> <li>solve simple routine</li> </ul>	<p><b>Data handling and Probability</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>use measures of central tendency and variability of distributions to make decisions and predictions</li> <li>interpret data</li> </ul>	<p><b>Data handling and Probability</b> Test writers should be able to</p> <ul style="list-style-type: none"> <li>interpret data represented in a number of ways</li> <li>recognise the impact of outliers on measures of central tendency and variability</li> </ul>

probability problems	represented graphically or in tables <ul data-bbox="434 156 678 256" style="list-style-type: none"><li>• use tree and Venn diagrams</li><li>• apply probability rules to solve problems</li></ul>	<ul data-bbox="725 102 1020 410" style="list-style-type: none"><li>• interpret and use measures of central tendency and standard deviation</li><li>• analyse predictions based on multiple data sets, and apply statistical reasoning in more complex problems</li><li>• solve more complex probability problems requiring the use of Venn and tree diagrams, and various probability rules</li></ul>
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## 2. NSC and NBT

### 2a. NBT TOPICS IN THE NSC CONTEXT

In the NSC, Mathematics in the FET Phase covers various content areas. Each content area contributes towards the acquisition of specific skills. The main topics in the FET Phase are: Functions; Number patterns, sequences and series; Finance, growth and decay; Algebra; Differential Calculus; Probability; Euclidean Geometry and measurement; Analytical Geometry; Trigonometry; Statistics (Department of Basic Education CURRICULUM AND ASSESSMENT POLICY STATEMENT (CAPS) FET BAND MATHEMATICS GRADES 10 – 12, p.12: [www.thutong.doe.gov.za](http://www.thutong.doe.gov.za), accessed 24/04/2015).

Schools are provided with a pace setter guide (see p. 22 of the CAPS FET Band Mathematics Grades 10 – 12 document; reference above), which ensures that Grade 12 learners have sufficient time for revision before the final Grade 12 exam. There are a few topics which the pace setter guide suggests leaving until the third quarter of the Grade 12 year. Knowing that many applicants to universities need to write the NBTs as early as the end of May, the MAT tests exclude topics that are unlikely to have been taught by that time.

In some schools, especially those following curricula other than the NSC, Grade 12 learners are already exposed to more advanced mathematical topics, for example A levels, Advanced Programme, etc. However, **it is assumed that studying advanced topics will not be possible unless learners already have a solid grounding in the topics that form part of the CAPS.** Such learners should then be well prepared in CAPS topics.

The questions in the MAT tests are embedded in the concepts set out in the CAPS, but the tests are not constrained to testing everything covered by the CAPS. Whereas the Academic Literacy and Quantitative Literacy tests are intended as tests of generic skills in these domains, the MAT tests focus more



on the specific knowledge and skills taught at school level, but are, as in the other domains as well, **explicitly designed to measure the preparedness of candidates for Higher Education**. The tests require writers to demonstrate sufficient understanding of concepts to enable them to apply those concepts in a variety of contexts. These higher order skills underlie success in Mathematics in Higher Education. These skills, developed deliberately in mathematical subjects such as Mathematics and Physical Science, are often implicitly expected by Higher Education institutions and are assumed in their curriculum design. **It is important for teachers to focus on the intended curriculum and not be constrained by trends in the examined curriculum.**

**QUESTIONS IN THE MAT TESTS ARE SET IN SUCH A WAY THAT CALCULATORS ARE NOT NEEDED. CALCULATORS ARE THUS NOT PERMITTED IN THE TESTS.**

An example of what we mean by this is given in the section dealing with sample questions.

## **2b. COMPLEMENTARITY OF NSC MATHEMATICS AND NBT MAT TESTS**

For many good reasons the MAT tests do not attempt to replicate the NSC Mathematics exam papers. The NSC exams are written by all Grade 12s, and must reflect the entire school mathematics curriculum. The MAT tests are written only by prospective students who intend studying courses for which mathematics is a requirement. While the MAT tests cannot test anything outside the school curriculum, they are not constrained to include all school mathematics topics, and thus elect to focus on those aspects of the school curriculum that have a greater bearing on performance in first-year mathematics courses. Clearly the NSC mathematics exams and the MAT tests should be seen as complementary forms of assessment.

The CAPS FET Band Mathematics Grades 10 – 12 document (see reference above) specifies a taxonomy of categories of cognitive demand, which indicate that learners need to perform at the levels of knowing (recall, or

basic factual knowledge are tested), performing routine procedures, performing complex procedures, and problem solving (see the CAPS FET Band Mathematics Grades 10 – 12 document, p. 55; reference above). These categories carry weights of approximately 20%, 35%, 30% and 15%, respectively.

The MAT tests are also differentiated in terms of cognitive levels, starting with lower order questions in order to facilitate an easy introduction into the test, and then progressing to questions that have greater cognitive demand. The MAT test items are differentiated into four cognitive levels. The highest level (counting for about 8%) comprises questions that involve greater insight, and the lowest level (about 45% of the total), comprises questions that involve knowledge, recall, and application of simple procedures.

Much attention has been given to the balance of questions in the MAT tests, to ensure that the relevant mathematical concepts have been covered, at the appropriate cognitive levels. **The tests all adhere to the same set of specifications, and are as equivalent as possible before they are written; real equivalence is guaranteed through a statistical equating process after the writing sessions so that the possibility that writers are disadvantaged by a particular form of a test is eliminated.**

## **2c. DIFFERENCES BETWEEN THE NSC MATHEMATICS EXAM AND THE MAT TESTS**

One difference between the MAT tests and the NSC Mathematics papers is that questions in the MAT tests do not cue the writers in any way. The practice of scaffolding questions does not take place. For example, in an NSC paper the following might appear:

Given a sketch, learners are asked:

*Calculate the gradient of AC. Hence, determine the equation of BN (where BN is shown on the sketch to be perpendicular to AC).*

In the MAT test the sketch would also be presented, but would then be followed by

*The equation of BN is ...* with four options to choose from.

Furthermore, in the MAT tests, no indication is given (for example by the fact that a question occurs in Paper 1 or in Paper 2) as to whether a question should be dealt with using geometrical or algebraic reasoning, by applying trigonometric principles, or by a combination of these. The fact that mathematics often requires learners to integrate many different skills and concepts in any given problem means that individual questions will assess across a range of mathematical competencies. For example, a question dealing with the graphical representation of a function may also assess spatial and algebraic competence. This means that writers must have a deep understanding of mathematics, and know what reasoning is appropriate in a given context; they will need these skills in Higher Education.

It may be assumed that multiple choice testing does not allow writers to obtain part marks for their reasoning in cases where they have reasoned correctly until the last step and then made a final careless mistake. This criticism is understandable, but the NBTP review process has, over a period of many years, made it possible to fine-tune the process of creating options for which this is unlikely. Firstly, if numerical reasoning is involved, the numbers are simple (sufficiently so to make calculators unnecessary); secondly the options given provide one correct answer and three others which are unlikely to have been reached by making careless mistakes. On the whole test writers must know what to do, in which case they find the correct option; or guess, in which case they choose one of the incorrect options. In some cases misconceptions are deliberately probed, so that one of the incorrect options will be a popular but incorrect answer. This practice can 'trap' students into selecting the incorrect option in a pressurised testing environment, so it is only occasionally used, since testing should create opportunities for writers to demonstrate what they know.

## WHAT CAN WE EXPECT FROM THE MAT TESTS?

### 3a. MAT TEST TOPICS

The topics from which test questions can be drawn are the following.

#### 1. PROBLEM SOLVING AND MODELLING

##### 1.1 Algebraic processes.

- Pattern recognition, sequences and series, use of sigma notation
- Operations involving relationships such as ratios and percentages
- Modelling situations by making use of mathematical process skills (translation from language to algebra, solution of problems)
- Operations involving surds, logarithms and exponents, including solution of exponential equations
- Financial calculations (compound interest, appreciation, future value, etc.)
- Number sense – manipulations/simple calculations involving integers, rational and irrational numbers
- Algebraic manipulation (includes expressions, equations, inequalities, simplification, factorisation, completing the square)

##### 1.2 Functions represented by graphs and equations; 'functions' to include linear, quadratic, hyperbola, cubic, exponential and logarithmic. Other graphs such as circles are also included.

- Comprehension of function notation, substitution, domain, range
- Function representation (algebraic and graphic); properties of functions and graphs (such as intercepts, turning points, asymptotes); relationship between graphs and their equations; interpretation of graphical information
- Transformations of graphs of the functions noted above; solution of related problems; inverses of functions
- Applications of principles of differential calculus and related problems involving simple linear, non-linear functions (i.e. critical points, increasing/decreasing functions, tangents); interpretation of behaviour of function from derivative and vice versa

## **2. BASIC TRIGONOMETRY, INCLUDING GRAPHS OF TRIGONOMETRIC FUNCTIONS, PROBLEMS REQUIRING SOLUTIONS OF TRIGONOMETRIC EQUATIONS AND APPLICATION OF TRIGONOMETRIC CONCEPTS**

- Definitions of trigonometric ratios (sine, cosine, tangent)
- Characteristics and interpretations of trigonometric functions and their graphs (e.g. domain, range, period, amplitude), including transformations of trigonometric functions
- Solving of trigonometric equations and using identities; simplification of trigonometric expressions using identities and reduction formulae where necessary; special angles; compound and double angles
- Application of area, sine and cosine rules
- Application of trigonometric concepts in solving problems, including two- and three-dimensional problems

## **3. SPATIAL PERCEPTION INCLUDING ANGLES, SYMMETRIES, MEASUREMENTS, REPRESENTATIONS AND INTERPRETATION OF TWO-DIMENSIONAL AND THREE-DIMENSIONAL SHAPES**

### **3.1 Geometric objects**

- Properties of 2D figures and 3D objects (such as the circle, rectangle, trapezium, sphere, cone, pyramid)
- Scale factor
- Perimeter, area, volume (also of composite figures and objects)

### **3.2 Analytic geometry** (linking geometric and algebraic properties in the Cartesian plane)

### **3.3 Circle Geometry**

- Cyclic quadrilaterals
- Relationships between tangents, and chords, and angles in a circle

## **4. DATA HANDLING and PROBABILITY**

- Measurement (and related interpretations)
- Representation (such as histograms, line graphs, pie charts, ogives, box-and-whisker plots) and related interpretations)
- Probability

**5. COMPETENT USE OF LOGICAL SKILLS IN MAKING DEDUCTIONS AND DETERMINING THE VALIDITY OF GIVEN ASSERTIONS**

### 3. WHAT SHOULD TEACHERS DO?

#### 4a. PRINCIPLES FOR PROACTIVE TEACHING

##### *Dealing with multiple choice questions*

Unless multiple choice questions are already being used in the classroom, it might be helpful to give learners some guidelines regarding how to deal with tests in this format. It would be helpful if teachers go through the following points, perhaps with some examples to make the principles clear.

- Read the question very carefully without looking at any of the possible options.
- Try to work out the question before looking at any of the possible options.
- Look at the options and see whether one of them corresponds to the answer that has been obtained, in which case select that option. **But** be critical of the reasoning involved, in case the answer reflects a specific misconception, as in the following example:

For  $x > 0$ ,  $\sqrt{9x^2 + 16x^2}$  is equal to

- (A)  $5x$       (B)  $7x$       (C)  $\pm 5x$       (D)  $\pm 7x$

Working out the question before looking at the answers, and being aware of the misconceptions that (a) the square root of a sum is not equal to the sum of the square roots, and (b) 'square root' is by definition positive, should help writers make the correct choice.

- **Pace yourself!** If none of the given options corresponds to the answer you have found, start the question over, and try once more. If none of the options is then found, leave the question for later and move on. All



questions have one correct option – this has been checked beforehand, and writers need not worry that there may be a mistake in the question.

- Questions in which it is possible to eliminate options by substitution are deliberately avoided. So, for example, there will not be questions asking for a specific solution to an equation, because it is easy to substitute each of the given options and find the correct one by elimination. For example, if we were to ask the following: “The solution of  $3x + 4 = -8$  is

$$(A) -4 \quad (B) -\frac{4}{3} \quad (C) 4 \quad (D) \frac{4}{3}$$

you can easily substitute  $-4$  and see that (A) must be the correct option.

### ***Helping learners prepare for the MAT tests***

The suggestions below are an attempt to guide teachers who want their learners to develop competence and skill in mathematics. The greater their competence, the better they will score in the NBTs.

- Ensure active engagement in class where learners are encouraged to ask questions (this pre-supposes solid teacher knowledge and understanding).
- Affirm learners – very few questions are stupid questions; all questions are opportunities for deeper and broader engagement.
- Develop learners’ conceptual understanding by asking them to explain their reasoning at all times.
- Make explicit the academic literacy skills needed in mathematics: it is easy to assume learners understand the nuances of the language of mathematics, but this is not necessarily the case. For example, do they understand the difference between ‘but’ and ‘and’, between ‘twice as much as’ and ‘two more than’; do they understand the language related to inequalities, such as ‘at least three units’ or ‘not more than 5’, etc.?



- Make explicit the quantitative skills required in mathematics. Since ratio, percentage, numerical manipulation, etc., are not specific skills required by the Grade 12 curriculum (although they are presupposed by the fact that they have been taught in the earlier grades), learners have often forgotten (or perhaps didn't ever understand) these quantitative concepts. In the MAT tests they can't use calculators, and must now demonstrate understanding of the relevant concepts. Undue dependence on calculators also programmes learners to lose arithmetic skill, and to lose their understanding of numbers, their relative size and position on a number line.
- Wherever possible consider alternative approaches to problem solving: could a geometric problem (area, volume) be approached from a trigonometric perspective, or could a trigonometric equation be solved using a trigonometric graph?
- Wherever possible, depend on mathematical concepts rather than calculators to solve problems. It is possible for a calculator to solve an equation, but does this show that the learner has understood the concepts required in solving equations? They may for instance not realise that the equation  $\frac{x^2(x+1)}{x} = 0$  has only one solution.
- **Most important: do learners understand?**

## 4. PREPARING FOR THE NBTs

### 5a. Internet assistance

We are aware that there are a number of people offering unwary learners the opportunity to download material off the internet which will prepare them to write the NBTs. While there may be sites that provide mathematical teaching, and others that give information relating to multiple-choice types of mathematics questions, **none of these has the authority to speak on behalf of the NBTP, and none of them have any special knowledge of what the NBTs aim to test.**

### 5b. Extra lessons

There are also many teachers who quite legitimately want to help their learners prepare for the NBTs. They will then be engaging with the points noted above, and doing their best to provide their learners with as solid a mathematical foundation as possible. However, **no teacher has the authority to speak on behalf of the NBTP**, neither do teachers have the authority to use the NBTP or HESA logo on any of their own material, which may create the impression that this is sanctioned by the NBTP.

## 5. FREQUENTLY ASKED QUESTIONS ABOUT THE MAT TESTS: TWO QUESTIONS THAT BOTHER PARENTS AND TEACHERS

### 1. *My child has done so well at school – why is his/her NBT score so low?*

To answer this we need to ask what does ‘so well’ mean? And what does ‘so low’ mean? Depending on the amount of drill and practice in particular types of tests and exams, it is possible for learners to get high marks on tests where questions

- follow an expected pattern;
- are scaffolded (see the comment earlier);
- have been frequently practised.

This does not necessarily mean that there is sufficient understanding of relevant topics, in the context required by Higher Education.

Writing the MAT test places writers into one of three categories (Basic, Intermediate, Proficient). There is no pass or fail, and writers are not ranked in relation to one another. The result simply assists the writer, and the institution to which he/she is applying, to determine appropriate levels of support that may be required, as soon as possible. If a writer is in the Proficient category, the actual score is not important and should not be compared with any mark obtained in a school test or exam, or even in the final NSC exam, which is a norm referenced assessment.

### 2. *When is the best time to write the MAT test?*

Writers need to choose the time of writing that enables them to meet the deadline of the institution to which they have applied. Our research suggests that there is in any case no advantage in waiting to write close to the NSC exam. The NBTP is mindful of the fact that some topics will only be dealt with

in the last few weeks of the teaching year, even though teachers are encouraged to follow the pace setter in order to allow time for revision and preparation for the final exams.

## 6. EXEMPLAR QUESTIONS

Examples are often helpful, although ‘teaching to the test’ limits real engagement with the mathematical topics that are being assessed. The NBTP does not make any NBT papers available for the public domain. In one sense this levels the playing fields: where for example past NSC papers are available, not all learners have access to them, or are drilled in working through them. The provision of a limited number of MAT examples on the website is also problematic: it simply isn’t possible to provide examples of all the sub-divisions of the mathematics topics, at all cognitive levels.

In the interests of answering the many questions directed to the NBTP call centre asking for some idea of what could be expected, a few sample questions are given below, to give a sense of the types of questions that could be expected.

### 6a. A FEW SAMPLE QUESTIONS

Questions in the section *Functions and their Graphs* will determine whether a test writer understands the properties of parabolas. Questions 1 and 2 are examples.

1. The function  $f$  defined by  $y = f(x) = -x^2 + 6x - 5$  has
  - (A) A minimum  $y$  value and a negative  $y$ -intercept.
  - (B) A maximum  $y$  value and a positive  $y$ -intercept.
  - (C) A minimum  $y$  value and a positive  $y$ -intercept.
  - (D) A maximum  $y$  value and a negative  $y$ -intercept.

Under the heading Algebraic Processes one of the topics listed is *Algebraic Manipulation*. Question 2 is an example of a question where the answer cannot be deduced by substituting into the given options to rule out those that are correct.

2. The sum of the roots of the equation  $-x^2 + 6x - 5 = 0$  is
- (A)  $-5$       (B)  $-4$       (C)  $3$       (D)  $6$

Another topic listed under the heading Algebraic Processes is *Number Sense*. The following question depends on *Number Sense* (the bigger a number, the bigger its square root) as well as the concepts tested in the first two questions above.

3. The expression  $\sqrt{-x^2 + 6x - 5}$  has a
- (A) maximum value of 2      (B) minimum value of 2  
(C) maximum value of 3      (D) minimum value of 3

Question 4 is an example of the category *Transformations* and related concepts.

4. If the graph of  $y = -x^2 + 6x - 5$  is reflected in the  $x$ -axis and the resulting graph is then reflected in the  $y$ -axis, the new equation is
- (A)  $y = -(x - 3)^2 + 4$       (B)  $y = -x^2 - 6x - 5$   
(C)  $y = (x + 3)^2 + 4$       (D)  $y = x^2 + 6x + 5$

One of the categories listed is *Competent use of logical skills in making deductions and determining the validity of given assertions*. Question 5 (which is also an example *Number Sense*) illustrates what this means. Writers need to assess the various options and make deductions about their validity.

5. For any real number  $x$ , which one of the following statements is **always** true?

(A)  $-x < 0$

(B)  $\frac{1}{x}$  is rational

(C)  $\frac{x}{x+1} < 1$

(D)  $\frac{1}{x} > 1$  if  $0 < x < 1$

The next two questions are in the *Trigonometry* category. Question 6 depends on an understanding of *compound angles*, and question 7 involves an application of *trigonometric ratios* in a two-dimensional situation.

6.  $\sin 43^\circ \cos 23^\circ - \cos 43^\circ \sin 23^\circ$  is equal to

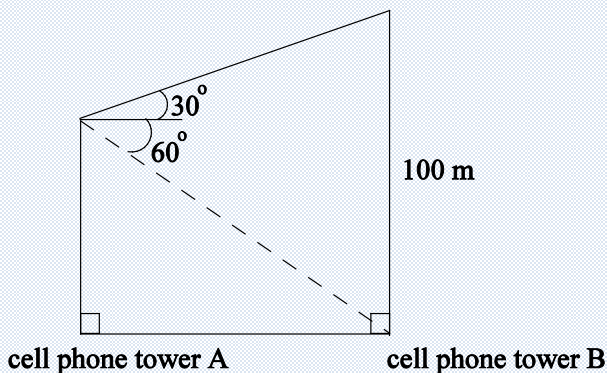
(A)  $\cos 66^\circ$

(B)  $\cos 20^\circ$

(C)  $\sin 66^\circ$

(D)  $\sin 20^\circ$

7.



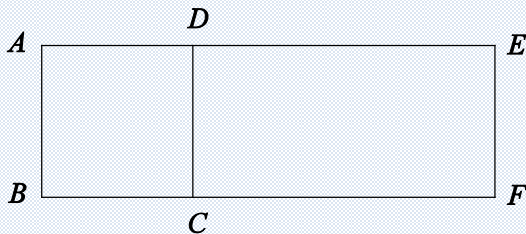
The angle of elevation of the top of cell phone tower B from the top of cell phone tower A is  $30^\circ$ . The angle of depression of the foot of cell

phone tower B from the top of cell phone tower A is  $60^\circ$ . The height of cell phone tower B is 100m. The foot of cell phone tower A and the foot of cell phone tower B are in the same horizontal plane. The height of cell phone tower A is

- (A) 60 m (B) 65 m (C) 70 m (D) 75 m

Question 8 combines an understanding of *Algebraic Manipulation* (in this case quadratics) and *Spatial Awareness* (rectangles) and Question 9 tests understanding of the *Properties of two- and three-dimensional objects*, as well as *surface area*.

8.

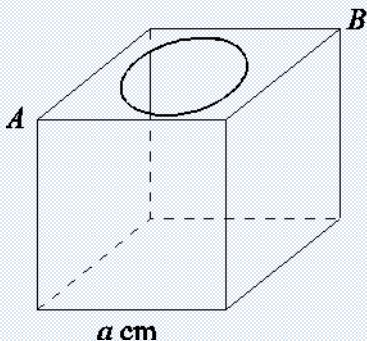


Suppose ABCD is a square with side length  $(x - 1)$  cm. If the area of rectangle ABFE is  $(x^2 + x - 2)$  cm<sup>2</sup>, then the length of FC, in cm, is

- (A) 2 (B) 3 (C) 4 (D) 5

Question 9 is also an example of *Spatial Awareness*.





9. The figure represents an empty cube with a circular opening at the top. The diameter of the opening is half the length of the diagonal  $AB$ . The outer surface area of the cube (in square centimetres) is:

- (A)  $6a^2 - \frac{\pi a^2}{4}$       (B)  $6a^2 - 2\pi a^2$   
 (C)  $6a^2 - \frac{\pi a^2}{8}$       (D)  $6a^2 - \frac{\pi a^2}{2}$

Question 10 (from the *Algebraic Processes* subcategory *Financial Calculations*) shows what we mean when we say that calculators are unnecessary.

10. An amount of R1 000 is invested at an annual interest rate of 6%. Interest is compounded **every three months** (quarterly). After 5 years the investment, in rands, will be worth

- (A)  $1\,000(1,015)^{20}$       (B)  $1\,000(1,02)^{15}$   
 (C)  $1\,000(1,03)^{20}$       (D)  $1\,000(1,06)^5$

The options given above show that we are interested in the *expression* you would use to carry out the calculation, and not in the final answer.