The Canterbury Academy Trust

Schools for all the Talents

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The Canterbury Academy

Numeracy and the Teaching of Mathematics across the Curriculum
Mathematical Calculations Handbook – Secondary Phase

I have ten boxes, which I want to pack into crates. Each crate can carry a maximum of 25kg.
I only have three crates and the total weight of the boxes is 75kg:
15kg, 13kg, 11kg, 10kg, 9kg, 8kg, 4kg, 2kg, 2kg, 1kg
How can I pack the boxes into the crates?

INTRODUCTION

To ensure consistency in teaching throughout The Canterbury Academy this Numeracy and Mathematical Calculations Handbook has been produced to incorporate the importance of numeracy and mathematical skills across the curriculum. This handbook will give an overview of the different strategies used in our school to teach mathematics throughout the Secondary Mathematics Curriculum.

Principles

At The Canterbury Academy we believe that numeracy is a fundamental life skill. It is our aim to develop an ethos in which numeracy is upheld as a key to success at school, further education or training and in society. Numeracy helps students to make sense of the world in which they live and wise financial decisions in the future. Building on experiences, it encourages thinking and reasoning skills to develop and helps to improve confidence to tackle situations that arise.
The new mathematics curriculum requires a deeper understanding to allow students to be able to use and apply skills and concepts. This improves students' ability to solve problems and progress to harder skills that rely on the students' understanding of prior learning. It is important to consider the impact of students' mathematical knowledge, understanding and skills on outcomes across the curriculum. Directors of Learning will need to liaise with the mathematical leaders for each Key Stage to ensure consistency and, where necessary, access the mathematics Scheme of Learning for additional guidance.

Numeracy across the curriculum will be supported through work with mentors. Each week students will complete a numeracy task with their mentor that is appropriate for their key stage. The tasks will focus on core numeracy skills and delivered through weekly presentations to provide a variety of tasks over a period of time. All tasks are designed for students to work independently so that they can improve their skills and understanding.

The teaching of numeracy and mathematics is the responsibility of all classroom staff in the Academy Trust; therefore, numeracy and mathematics will be imbedded in the teaching and learning of all lessons.

NEED FOR A WHOLE SCHOOL APPROACH

Improving numeracy and mathematical skills is a whole-school matter. Each department should identify the contribution it can make towards the teaching of numeracy and other mathematical skills. So that students become confident in tackling mathematics in any context.
The teaching of numeracy and mathematical skills is the responsibility of all staff and the school's approaches should be as consistent as possible across the curriculum.

All teachers should consider pupils' ability to cope with the numerical demands of everyday life and provide opportunities for students to:
Handle number and measurement competently, mentally, orally and in writing;
Use calculators accurately and appropriately.
Interpret and use numerical and statistical data represented in a variety of forms.
Staff need to look for opportunities for drawing mathematical experience out of a wide range of children's activities. Mathematics contributes to many subjects of the curriculum, often in practical ways. Activities such as recording the growth of a plant or an animal, measuring temperature and rainfall, or investigating the cogwheels in a bicycle can provide data or starting points for discussion and the opportunities to apply and use mathematics in real contexts. The key to making the most of all these opportunities is to identify the mathematical possibilities in your subject at the planning stage.
As already stated in the introduction it is important to consider the impact of students' mathematical knowledge, understanding and skills on outcomes across the curriculum. As the GCSE and A level courses become harder with increased content Directors of Learning will need to ensure that any numeracy and mathematical skills that are needed within any GCSE or A level subject is well taught. Access to the mathematics SOL for every year group and set can be found by logging into Active Learn and/or by accessing the mathematics staff shared drive and/or through discussion with the Director of Teaching and Learning for mathematics, (DoTL), appropriate Key Stage manager for mathematics or the Numeracy Coordinator.

ROLES AND RESPONSIBILITIES
Executive Principal, Heads of Schools and Directors of Teaching & Learning
• Support the use of appropriate teaching strategies by allocating resources effectively.
• Ensure that the school buildings and premises are best used to support successful teaching and learning.
• Monitor how effective teaching and learning strategies are in terms of raising pupil attainment.
• Ensure that staff development and performance management policies promote good quality teaching.

Class Teachers
All staff have high expectations that all children can achieve their full potential.
Provide opportunities for using cross curricular mathematical techniques.
Provide examples of numeracy in everyday situations.
Schemes of Work to have a numeracy focus where relevant.

Cross Curricular Numeracy Coordinator
To work with the DoTL for mathematics, the Key Stage managers in mathematics and each subject area to ensure that schemes of work exploit opportunities to improve mathematical understanding.
To develop numeracy events for Year 7 and Year 8; cross curricular days, activities
To develop a clear programme of numerical activities for mentors to use with their mentees.
To work with the Heads of Year to ensure that Mentors are able to consistently ensure that they can deliver the planned numeracy programme of activities and tasks.
To work with colleagues in the mathematics to ensure that the Primary mathematics curriculum is used to ensure progress and continuity is maintained during transition.
To be a champion for numeracy; assemblies, displays, newsletters and parents' evenings.
To provide professional development for staff with the DoTL for mathematics and the Key Stage managers in mathematics to ensure confident delivery of mathematical skills and concepts across the curriculum.

To identify mathematical techniques which can be used across the school.
To ensure that the mathematical department has a calculator policy for numeracy, which all staff can use consistently across the curriculum.
To ensure that a strategic action plan to improve numeracy is included within the mathematics action plan
To coordinate the implementation of numeracy activities at times outside of lessons

Subject Numeracy Link in the Secondary School
Every subject area should have a designated numeracy representative. Their role is to quality assure the teaching of numeracy and mathematical calculations within their subject area and provide a link whereby information can be shared between the numeracy coordinator, DoTL for mathematics, intervention teams and teaching staff.

CROSS-CURRICULAR GUIDANCE
This document should provide information and guidelines to help produce consistency across the curriculum - it is not intended to be a prescription for teaching although some advice is given.

Approaches
It is recognised that not all students in a teaching group will have the same numerical skills and where unsure of an appropriate 'numerical level' teachers should consult with the Mathematics Department.
All teachers should discourage students from writing down answers only and encourage students to show their numerical working out within the main body of their work.
All teachers should encourage the use of estimation particularly for checking work.
All teachers should encourage students to write mathematically correct statements.

Basics
When students come to The Canterbury Academy they start a varied curriculum with many different teachers. However, it is still important that they practise their basic number work, which may not be reinforced as often as it was in primary school. Teachers should refer to the CPS Calculation Handbook for additional information when teaching students in Year 7. Every student should know their tables, particularly as they progress through the school. Their six, seven, eight, and nine times tables are very important and can be practised at home but any opportunity across the curriculum to work with single digit mental calculations can only assist progress in mathematics.
In all arithmetic, the importance of place value and neat column keeping should be stressed. In a line of workings an “equals” sign should only appear once.
This is poor practice: £3.50 x 0.85 = 2.975 + 3.50 = 6.475 = £6.48
This is good practice: £3.50 x 0.85 = 2.975
2.98 + 3.50 = £6.48
Primary School learning about place value is often forgotten and can also be reinforced at every opportunity across the curriculum.
Remember. The number one million, two hundred and thirty four thousand, five hundred and sixty seven point eight nine one would be set out as follows:
Millions. Hundreds of thousands. Tens of thousands. Thousands. Hundreds. Tens. Units. Decimal Point. Tenths. Hundredths. Thousandths
1 234 567.891 (Commas should NOT be used as this can be mistaken for decimal points in more than one place.)

Calculators
In order to improve numeracy skills, it is essential that students should be encouraged to use non-calculator methods whenever possible. However, departments should ensure students have access to calculators when they are necessary.

It is recognised that where calculators are to be used their correct use may have to be taught.
Methods and Presentation
Where a student is gaining success with a particular method it is important that s/he is not confused by being given another method. It is recognised that there is never only one correct method. Students should be encouraged to develop their own correct methods, where appropriate, rather than be taught 'set' ways. However, this document outlines many of the preferred methods that allow students to progress to harder skills and concepts.
All students should be helped to understand the methods they are using or being taught. Students gain more, and are likely to remember much more easily, if they understand rather than are merely repeating by rote.
Language: When referring to decimals say "three point one four" rather than "three point fourteen".
Read numbers out in full, so say three thousand four hundred rather than three, four, zero zero.
It is important to use the correct mathematical term for the type of average being used, i.e. mean, median or mode.
Mean: Total of values of sample ÷ sample size. [The term average is commonly used when referring to the mean]
Median: Middle value of sample when sample values are arranged in size order.
Mode: Sample values which occur most frequently.

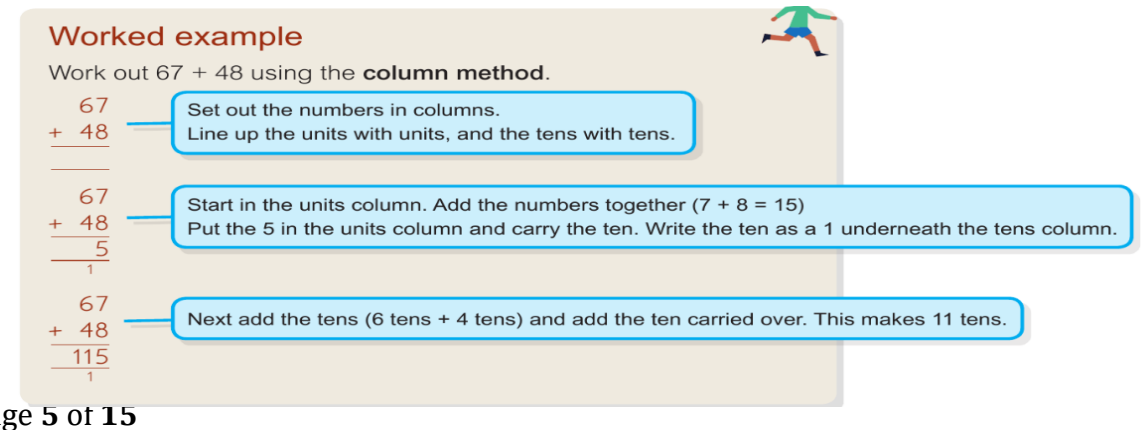
TOPICS

Measure and Estimate
Most students will be secure in…
Measuring and estimating height and length in cm, m, 1/2 m, 1/10 m
Volume in litres, 1/2 litres, 1/4 litres
Reading scales on measuring devices where an intermediate graduation may be deduced.
Some students will be secure in...
Estimating small weights, small areas, small volumes
Measuring height and length in mm
Understanding that 1 litre = 1000 ml.
Being aware of common imperial units.
A few students will be secure in...
Estimating areas in square metres, cm and mm
Reading scales, estimating between graduations.
Rough Conversions between Metric and Imperial:
In the mathematics department we teach the following conversions:
1inch = 2.5cm 1yard = 1m 1kg = 2.2lbs 2pints=1litre 1mile=1.6km 1oz = 25g 5 miles = 8km
Students should be expected to record the units they are using when answering a question.

Rounding
Most students will be secure in..
Rounding 3 digit whole numbers to the nearest 10
Rounding any number to the nearest whole number, 10 or 100
Some students will be secure in..
Rounding any number to 1 decimal place
Few students will be secure in..
Rounding to any number of decimal places or significant figures
Note: We always round up for 5 or above
WORKED EXAMPLES:

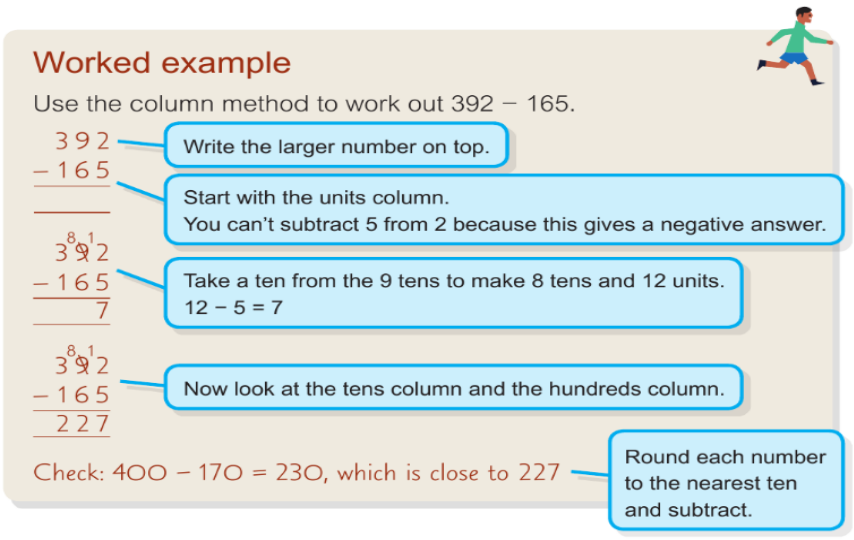
To the nearest 10	74 becomes 70	385 becomes 390
To 1 decimal place	7.51 becomes 7.5	8.96 becomes 9.0
To 3 significant figures	3.04559 becomes 3.05	3054 becomes 3050
To 2 significant figures	3.04159 becomes 3.0	3054 becomes 3100

Addition
Most students will be secure in..
Addition using the column method
Using alternative mental methods where appropriate
Using a calculator to add numbers.
WORKED EXAMPLE:



Subtraction
Most students will be secure in..
Subtraction using the column method
Checking by addition
Using alternative mental methods where appropriate
Using a calculator to subtract numbers.

WORKED EXAMPLES

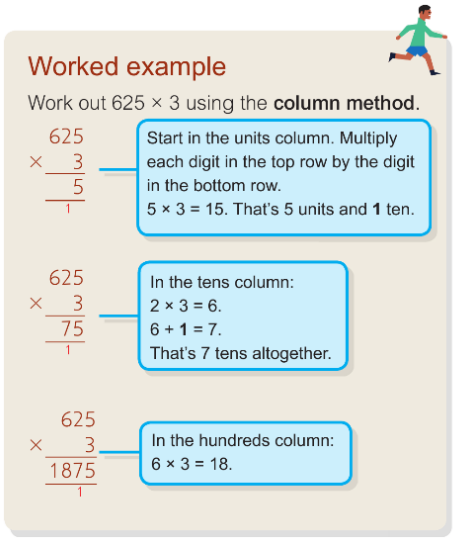


Multiplication
Most students will be secure in..
Multiplying numbers by 10, 100 and 1000
Multiplying one digit number by another one digit number
The 2, 3, 4, 5, 9, 10 and 11 times tables
Multiplying a two digit number by a one digit number
Using a calculator to multiply numbers.

Some students will be secure in..
Multiplying numbers by 10000, 100000 and 0.1, 0.01, 0.001
The 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 times tables.
Multiplying a two digit number by a two digit number.
Multiplying a three number by a two or three digit number.

WORKED EXAMPLES

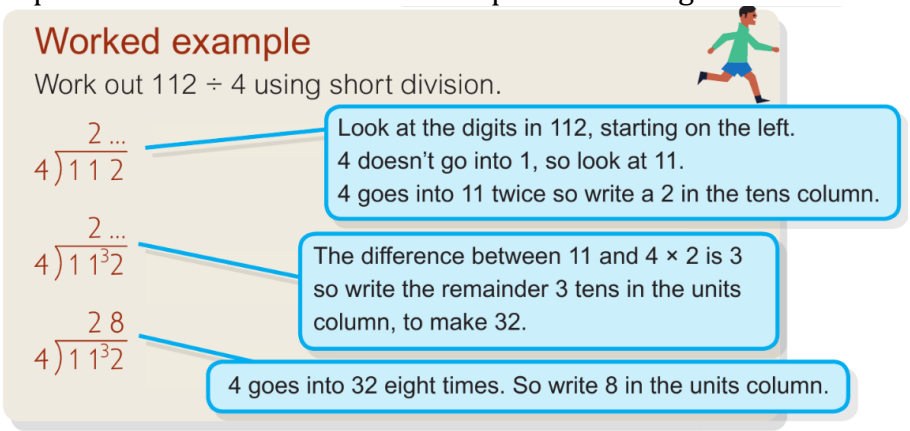
When multiplying by ten do not teach the 'rule' add a nought or move the decimal point along one but rather explain that the number moves one place to the left relative to the decimal place.



Division
Most students will be secure in..
Dividing numbers by 10, 100 and 1000
Dividing a two digit number by a one digit number (Short division)
Dividing a three digit number by a one digit number
Dividing a two digit number by a smaller two digit number.
Using a calculator to divide numbers.

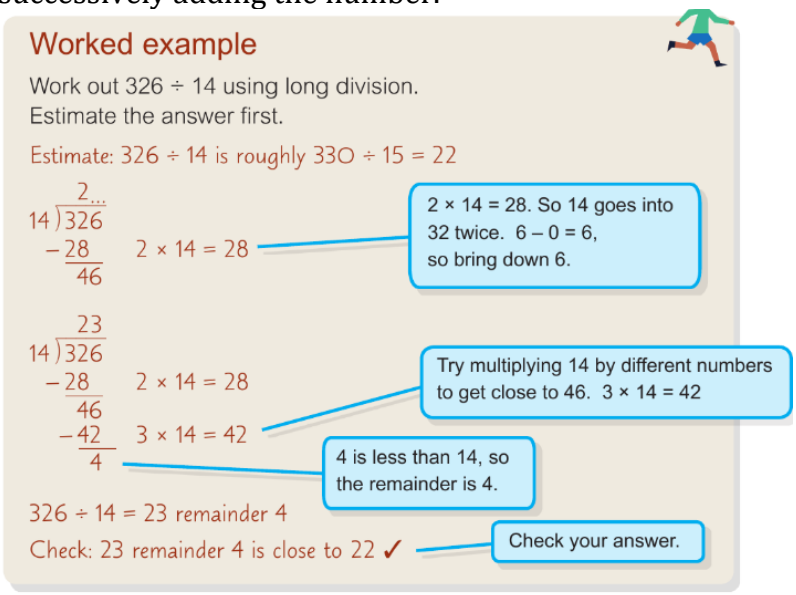
Some students will be secure in..
Dividing numbers by 10000, 100000 and 0.1, 0.01, 0.001
Dividing a three or four digit number by a two digit number. (Long division)

Few students will be secure in..
Dividing any number by a smaller number with a remainder. (Long division)
WORKED EXAMPLES
When dividing by ten do not teach the 'rule' move the decimal point along one but rather explain that the number moves one place to the right relative to the decimal place.



Long division

Students should be encouraged to write multiples of the divisor to help solve the problem by successively adding the number.



Order of Operations (BODMAS)

BODMAS is a mnemonic, which we teach in mathematics to enable students to know exactly the right sequence for carrying out mathematical operations.

Scientific calculators use this rule to know which answer to calculate when given a string of numbers to add, subtract, multiply, divide etc.

For example What is the answer to 2 + 3 x 5?

Is it (2 + 3) x 5 = 5 x 5 = 25 ? or 2 + (3x5) = 2 + 15 = 17 ?

We use BODMAS to give the correct answer:

Do the following operations in order (B)rackets (O)f (D)ivision (M)ultiplication (A)ddition (S)ubtraction

According to BODMAS, multiplication should always be done before addition, therefore 17 is the correct answer and should also be the answer which your calculator will give if you type in 2 + 3 x 5 <enter>.

Of refers to "Powers OF" i.e. a number raised to a power, e.g. 2^3 is 2 to the power OF 3.The power is also called the exponent or index leading to an alternative mnemonic BEDMAS or BIDMAS but both mean the same thing.

WORKED EXAMPLE:

Calculate $4 + 70 \div 10 \times (1+2)^2 - 1$

Brackets first $4+70\div10\times32 -1$

Of next $4 + 70 \div 10 \times 9 -1$

Division $4 +7 \times 9-1$

Multiplication $4 + 63 -1$

Addition $67 -1$

Subtraction 66

Answer is 66

Fractions

Most students will be secure in ...

Calculating simple fractions of 1 or 2 digit numbers e.g

$\frac{1}{3}$ of 9 = 3 (9 ÷ 3)

Calculating simple fractions of up to 4 digit numbers e.g

$\frac{3}{4}$ of 176 = 132 (176 ÷ 4) x 3

Some pupils will be secure in..

Using equivalence of widely used fractions and decimals e.g. $\frac{10}{3}$ = 0.3

Finding widely used fractions mentally e.g. $\frac{1}{2}$ $\frac{1}{4}$

Finding fractions of a quantity with a calculator

Few students will be secure in..

Use of equivalence of all fractions, decimals and percentages

Adding, subtracting, multiplying and dividing fractions with and without a calculator

WORKED EXAMPLES

Add and Subtract

Make the denominators equal

Key point 2

To add or subtract fractions, write them with a common denominator.

Example 2

Work out $\frac{2}{3} + \frac{1}{9}$.

$\frac{2}{3} + \frac{1}{9} = \frac{6}{9} + \frac{1}{9} = \frac{7}{9}$

The LCM of 3 and 9 is 9. Write the fractions with denominator 9 and then add.

Multiply

Multiply numerator and denominator, (top and bottom)

Key point 5

To multiply fractions together, multiply the numerators together and the denominators together.

Example 5

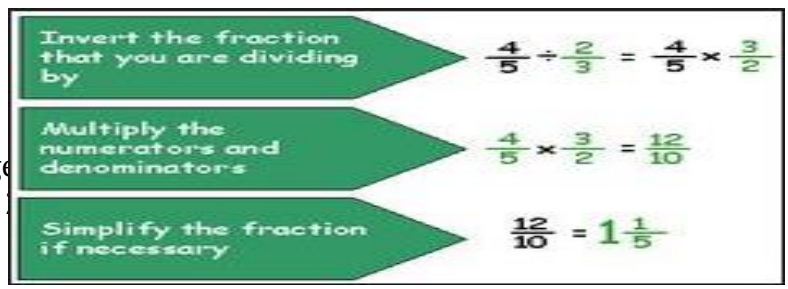
Work out $\frac{2}{3} \times \frac{1}{5}$.

$\frac{2}{3} \times \frac{1}{5} = \frac{2 \times 1}{3 \times 5} = \frac{2}{15}$

Multiply the numerators and the denominators.

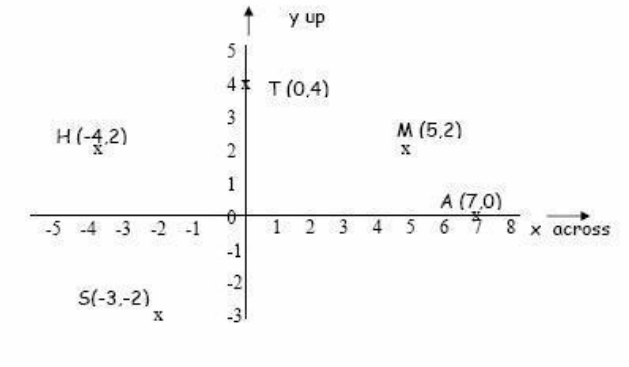
Divide

Invert the second fraction and then multiply.



Co-ordinates

Most students will be secure in..
Using a co-ordinate system to locate a point on a grid in the positive quadrant only e.g. (4, 6)
Numbering the grid lines rather than the spaces
Using the terms across/back and up/down for the X and Y directions
(mnemonic "X is a cross, wise up")
Using a comma to separate as follows : 3 across 4 up = (3, 4)
Using an 8 point compass rose to describe position or direction
Some students will be secure in..
Use of co-ordinates in all four quadrants to plot positions
Using 3 figure bearings for position, direction from North e.g east is 090
WORKED EXAMPLE:
Plot the following points: M (5,2), A (7,0), T (0,4), H (-4,2), S (-3,-2)



Percentages
Some students will be secure in..
Finding 50%, 25%, 10% and 1% without a calculator and using addition to find other amounts such as 15% (add 10% and 5%)
Finding percentages with a calculator (e.g 23% of £300 = 300 ÷ 100 x 23 = £69) recognising that "of" means multiply
Few students will be secure in:
Expressing a fraction as a percentage via the decimal equivalent
WORKED EXAMPLES
NON-CALCULATOR
Find 36% of £250
10% is £25
30% is £75 (10% x 3)
5% is £12.50 (10% ÷ 2)
1% is £ 2.50 (10% ÷ 10)
So 36% is £90 (30% + 5% + 1%)
CALCULATOR
Find 36% of £250
36 ÷ 100 X 250

£90

Express $\frac{2}{5}$ as a percentage

$\frac{2}{5} = \frac{4}{10} = \frac{40}{100} = 40\%$

Calculator

Express $\frac{9}{13}$ as a percentage

9 ÷ 13 X 100= 69.2%

BE VERY CAREFUL if using the % button on the calculator because of inconsistencies between models.

Proportion

Few students will be secure in..

Identifying direct proportion

Recording appropriate "headings" with the unknown on the right

Using the unitary method (i.e. find the value of 'one' first then multiply by the required value)

If rounding is required we do not round until the last stage

WORKED EXAMPLE:

If 5 bananas cost 80 pence, then what do 3 bananas cost?

Bananas cost (pence)

5 cost 80

1 cost 80 ÷ 5 = 16

3 cost 16 x 3 = 48pence

Equations

Some students will be secure in solving simple equations by .....

Doing "Undo" operations e.g

undo + with -, undo – with +

undo x with ÷, undo ÷ with x

Using the 'balancing method'

We prefer the letter ***x*** to be written differently from a multiplication sign, one equals sign per line and equals signs beneath each other.

We discourage bad form such as 3 x 4 = 12 ÷ 2 = 6 x 3 = 18

WORKED EXAMPLES:

2y + 3 = 9 undo the +3 by subtracting 3 from the right side

2y = 6 undo the times 2 by dividing by 2 on the right side

y = 3

To solve: 3y – 7=5 Balance Method:

3y – 7=5 (add7tobothsides)

3y – 7 + 7 = 5 + 7

3y = 12 (divide both sides by 3)

3y ÷ 3 = 12 ÷ 3

y = 4

The terms “cross multiply” and “swap sides - swap signs” can lead to misunderstandings, as part of any explanation of how to solve equations and so should be avoided. DO NOT say “change the side, change the sign “ or “flip over and change the sign”.

Types of Data

Discrete Data

Data is described as discrete if specific values only can be used, e.g. shoe size is discrete as sizes such
4.8 and 5.77 cannot exist.

Continuous Data

Data is described as continuous if all values can exist, eg. height and weight are continuous data as potentially any value could be measured.

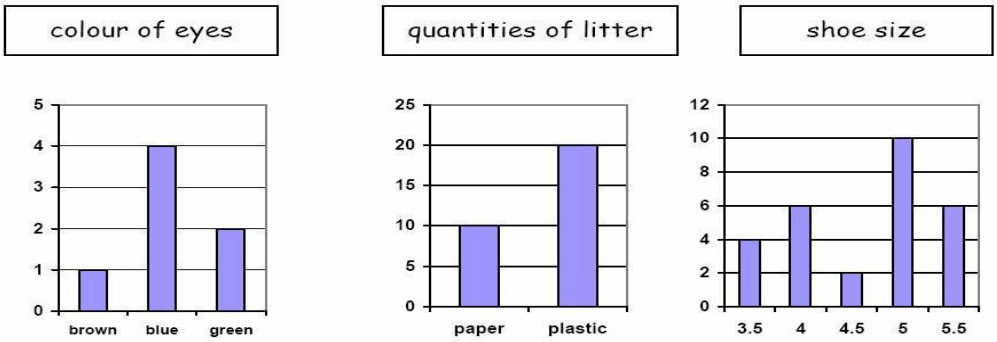
Line Graphs

Most students will be secure in.
Using a sharpened pencil and a ruler.
Choosing an appropriate scale for the axes to fit the paper.
Labelling the axes.
Giving the graph a title.
Numbering the lines not the spaces.
Plotting the points neatly (using a cross or dot).
Fitting a suitable line by joining point to point with a straight line.
(Lines of best fit not covered until GCSE Grade 3 or 4)

Bar Chart

The bars should be of equal width and equally spaced. The bars do not have to touch for discrete data frequency should be on the y (vertical) axis.
All pupils will be secure in.
Giving the chart a title.
Labelling the axes.
Labelling the bars in the centre of the bar (each bar has an equal width).
Using a pencil.
Labelling the frequency (up the side) on the lines, not on the spaces.
Making sure there are spaces between the bars.
All students construct bar charts with frequency graduated in single units.
Most pupils construct bar charts with frequency graduated in multiple units.
Most pupils construct bar charts involving simple fractions or decimals.

WORKED EXAMPLES:

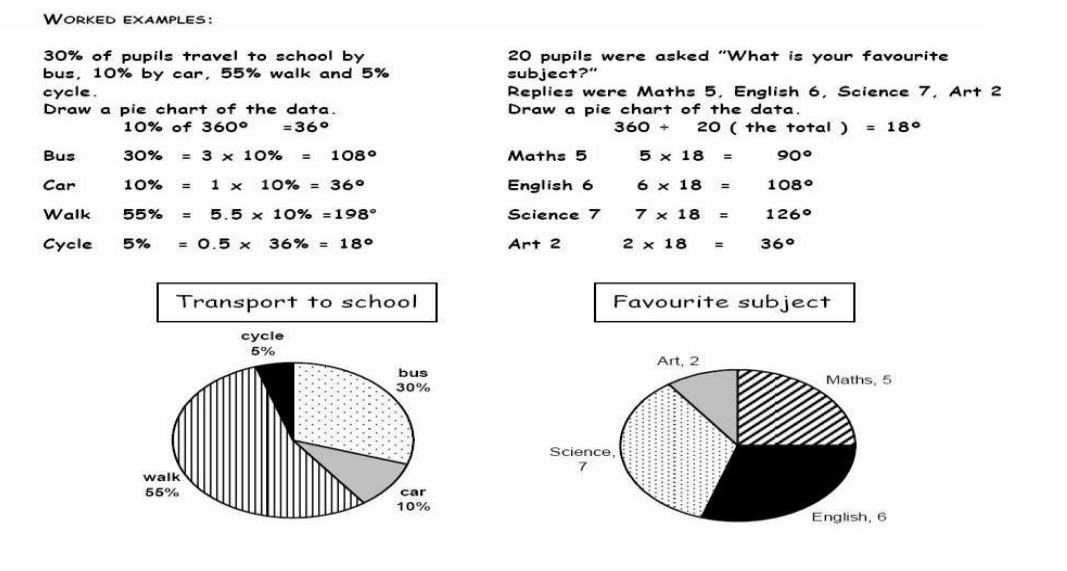


Pie Charts

All students will be secure in.
Using a pencil.
Labelling all the slices or use a key as required
Giving the pie chart a title.
Some students will be secure in.
Constructing pie charts involving simple fractions or decimals.
Constructing pie charts of data expressed in percentages.
Few students will be secure in.

Constructing pie charts of raw data.

Sectors should be labelled (e.g. Car, Blue....) or there should be a key. Do not be surprised if the total of all the angles is 360° plus or minus one or two degrees. This will almost certainly be due to the rounding that may be necessary. In these cases either add or take the one or two degrees from the largest angle.



Histograms
Do not use the term Histogram unless the relative frequency is plotted along the y axis. Bars are likely to have different widths. This is only taught to students in the top sets, (Higher paper), in Years 10 and 11. Students need to appreciate the connection between the area and the frequency. Histograms DO NOT have spaces between the bars.

Time Calculations
Most students will be secure in..
Converting between 12 and 24 hour clock (2327 = 11.27pm, 0000 = midnight)
Calculating duration in hours and minutes by counting up to the next hour and then on to the required time
Some students will be secure in
Converting between hours and minutes (multiply by 60 for hours into minutes)
Worked Examples:
How long is it from 0755 to 0948
0755 to 0800 to 0900 to 0948
(5 mins) + (1 hour) + (48 mins)
Total time 1 hr 53 minutes
Change 27 minutes in to hours equivalent
27 min = 27 ÷ 60 = 0.45 hours
Pupils should never record 3hrs and 30 mins as 3.30hrs but as 3.5hrs.
[When working with time it is possible to use the degrees/mins/secs key on many calculators.]
Using Formulae
We expect most students to construct and use formulae by
Writing down the formula first, substituting the given numerical values in to the formula then solving the equation
Interpreting the answer including the correct units
WORKED EXAMPLES:
The length of a spring S mm for the weight of W grams is given by the formula: S = 16 + 3W
Find S when W = 3g
S = 16 +3W (write the formula)
S = 16 + (3 x 3) (replace letters by numbers)
S = 16 + 9 (solve the equation)
S = 25
Length of string is 25 mm (interpret result in context)
Find W when S = 20.5 mm
S = 16 +3W (write the formula)
20.5 = 16 + 3W (replace letters by numbers)
4.5 = 3W (solve the equation – by doing and undoing)
1.5 = W
The weight is 1.5 g (interpret result in context)
Do not rearrange the formula before substitution. State the answer only. Working must be shown.

Data Analysis
Some students will be secure in
Analysing ungrouped data using a tally table and frequency column or an ordered list
Calculating the range of a data set. In mathematics this is taught as the difference between the highest and lowest values of the data set.
Calculating the mean average of a set of data
Few students will be secure in
Calculating the median (central value of an ordered list)

Mode (most common value) of a data set.
Obtaining these values from a frequency table
Correlation in scatter graphs is described in qualitative terms.
e.g. “The warmer the weather, the less you spend on heating” is negative correlation.
“The more people in your family, the more you spend on food” is positive correlation.
Probability is always expressed as a fraction P (event) = Number of favourable outcomes
Total number of possible outcomes

WORKED EXAMPLES
The results of a survey of a number of pets that pupils owned were 3,3,4,4,4,5,6,6,7,8
Mean. (3 + 3 + 4 + 4 + 4 + 5 + 6 + 6 + 7 + 8) ÷ 10 = 5
Median. The middle (3, 3, 4, 4, 4, 5, 6, 6, 7, 8) (Middle is between 4 and 5)
(4 + 5) ÷ 2 = 4.5
Mode. Most common = 4
Range. Highest – lowest.
8 – 3 = 5

Solutions to crate puzzle.
There are ten possible answers – have you found all ten solutions?
(Maths is Fun – A Weighty Problem Puzzle – mathsisfun.com)