Using Algebra, Functions and Graphs Work Scheme

This FSMQ requires a total of 60 guided learning hours that could be timetabled in a variety of ways eg 2 hours per week for 30 weeks, 4 hours per week for 15 weeks, 5 hours per week for 12 weeks. A suggested work scheme showing topics and methods to be covered is given below. Although the topics are listed separately, it would often be beneficial to use a variety of skills within the same piece of work. Some terms and techniques should be introduced as soon as possible and used throughout the course. These include:

- using a calculator effectively and efficiently, including the use of standard form for large and small values
- doing calculations without a calculator using written methods and mental techniques
- recording and presenting data in tables using an appropriate degree of accuracy and correct units (grouping data where appropriate)
- graph plotting by hand and using either computer software or a graphical calculator
- checking calculations using estimation, inverse operations and different methods.

Topic Area	Content	Nuffield Resource	Coursework Portfolio Requirements
Plot Graphs of Real Data (4 hours)	Plot accurate graphs of data pairs by hand and using either a graphic calculator or function plotting software, ensuring that the graphs are correctly scaled and labelled. Average data if necessary (mean, mode, median). Fit by eye, lines, both straight and curved, as appropriate. Find the intercepts of linear and non-linear graphs with axes and where appropriate understand their physical significance. Identify errors in data by inspection of the data set and by graphical means. Recognise that measurements expressed to a given unit can have a maximum error of half a unit; using notation such as 300±50 to express errors.	**Road Test** (starter) Use data from a road test on a sports car for practice in drawing and interpreting graphs. Optional use of spreadsheet.	Reports of ***two or more investigations*** that bring together the three major areas: a) graphs of real data b) linear, proportional and non-linear models c) use of algebra. Ideally students should investigate real situations from their other areas of study, work or interests and they should use their own data wherever possible. When taken together the reports should include the requirements listed on the following pages. The way in which these requirements are split between the investigations will depend to a large degree on the contexts involved. In order to begin portfolio work as soon as possible, teachers will need to plan the order in which they cover topics carefully. The order suggested here may not be the most suitable for some groups and it may well be more appropriate to cover parts of each topic area at separate times, rather than as a block as listed here.
Gradients (2 hours)	Calculate in appropriate units and understand the physical significance of: • the gradients of linear graphs • the gradients at points on non-linear graphs by drawing tangents (make use of graphs already drawn)	**Hire a Coach** (starter) Introduces the concepts of gradient and intercept for linear graphs using Excel.	
Standard Form (1 hour)	Convert between standard form and ordinary numbers. Use a calculator to perform calculations with numbers expressed in standard form.	**Large and Small** (starter) Powerpoint presentation and examples from real contexts to introduce, practise or revise standard form.	

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Graphs of Functions (5 hours)	Use functions to find data pairs $y = mx + c$, $y = kx^2 + c$, $y = ax^2 + bx + c$, $y = kx^3$, $y = \frac{k}{x}$, $y = ka^{mx}$, $y = ka^{-mx}$, functions with other variables eg $P = \frac{k}{V}$. Use function notation eg $f(x) = kx^2 + c$ Plot graphs, using co-ordinates in all four quadrants. Recognise the main features of graphs of direct proportional, linear, quadratic and inverse proportional functions.	**Linear Graphs** (starter) Powerpoint presentation and activity to introduce linear graphs. **Graphs of Functions in Excel** (starter) This activity shows students how to draw graphs of algebraic functions in Excel. **Spreadsheet Graphs** (skills activity) Interactive spreadsheet graphs introducing the shape and main features of proportional, linear, inverse proportional and quadratic graphs. **Linear Relationships** (skills activity) Example and exercise involving proportionality and other linear relationships in scientific contexts. **Quadratic Graphs** (skills activity) Powerpoint presentation, notes and exercise on drawing quadratic graphs and using them to solve equations.	**a)** • Plot (i) data (ii) at least one linear model (iii) at least one non-linear model at least one plotted by hand and at least one plotted using a graphic calculator or computer software. • Explain how each graph relates to what is happening in the real world situation by identifying and calculating any appropriate key features including (i) intercepts with axes (ii) gradients (iii) areas under graphs. • Predict what will happen for cases for which there is no data.
Substitution into Formulae including **Conversion of Units** (2 hours)	Convert within and between metric and imperial systems, including inches, feet, yards, miles using conversion factors and the use of formulae eg $L = 3.28l$ for converting metres to feet. Substitute data into other formulae to find secondary data including formulae with multiples and fractions of linear terms, powers (positive and negative integers and fractions) and brackets.	**Formulae** (skills activity) Powerpoint presentation, notes and exercise including a range of formulae involving areas and volumes, interest calculations, temperature conversion and equations of motion.	• Solve problems involving (i) linear, and (ii) non-linear functions. N.B. Graphs must be correctly scaled, labelled & plotted. Data from graphs should be quoted to an appropriate degree of accuracy and graphs should indicate how these have been found. Students should explain how inaccuracies in data may affect interpretation of the graphs.
Re-arrange Algebraic Expressions (3 hours)	Rearrange algebraic expressions by: (i) collecting like terms eg sums and differences of terms such as, na, nab, na^2 (ii) expanding brackets eg $2(x + y)$, $a(2a + 3b)$, $\frac{1}{2}(4x^2 + 6x)$ (iii) extracting common factors eg expressions such as $(4x + 6x^2)$, $(16y - 8xy)$		

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Areas under Graphs (3 hours)	Calculate estimates of areas under graphs and understand their physical significance (if any) using the formula for the area of a trapezium (and triangle if necessary)	**Area under a graph** (starter) Powerpoint to introduce area under a velocity-time graph accompanied by examples for students to try. Optional use of spreadsheet/graphic calculator.	**b)** Find: • one linear or proportional function to model data (using the gradient and intercept on the vertical axis) (N.B. Students should identify and find for themselves the appropriate function.) • one non-linear function to model data
Rearrange Formulae (4 hours)	Include examples such as: ▪ to give u if $v = u + 10t$ ▪ to give I if $P = 1000\,I^2$ or $P = I^2R$ ▪ to give P if $A = P + \frac{PRT}{100}$	**Rearrange Formulae** (skills activity) A wide range of formulae from real contexts (areas, volumes, interest calculations, temperature conversion, equations of motion etc) for students to rearrange. Includes cards that can be used to help students with the most difficult cases.	
Line and Curve Fitting (5 hours)	Recognise the main features of the data and graphs of: • direct proportional ($y = mx$) and linear ($y = mx + c$) models and be aware of their differences • quadratic models of the form $y = kx^2$ Recognise the graphs of inverse proportional models Predict the shapes of graphs of direct and inverse proportion, linear and quadratic functions from an algebraic statement. Use the gradient and intercept of a straight line fitted to data to find an algebraic statement for it. Understand when it is appropriate or not to use a particular function to model data by consideration of intercepts, long term behaviour etc. in real world terms. Find a function to fit data using substitution of values into a given expression for the model $\left(y = mx + c,\ y = kx^2 + c,\ y = \frac{k}{x} \right)$	**Match linear functions and graphs** (skills activity) 12 sets of cards, each containing a linear graph, its equation and the real situation it represents – for students to match.	
		Road Test Data (skills activity) Includes data from a road test on a sports car. Worksheet giving practice in fitting linear and quadratic functions. Optional use of spreadsheet.	
		Boyle's Law (assignment) Data sheet giving pressure and volume of a fixed mass of gas, an assignment and sample examination question based on this experimental data.	
		Shoot (assignment) Students investigate the distance travelled by an object rolling down an inclined plane using graphical and algebraic techniques. Includes a guidance sheet.	
		Experiments (skills activity) List of seven experiments that generate linear and non-linear data. Students find appropriate algebraic models.	

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Solve Equations (4 hours)	Using graphs ▪ to determine a value of a when you know $f(a)$ ▪ to solve equations involving functions of the form $y = mx + c$, $y = kx^2 + c$, $y = kx^3$, $y = \frac{k}{x}$, and other functions useful to students' other work. Using algebra • to form and solve exactly equations where the unknown appears in only one term including where the unknown is squared e.g $2x^2 + 14 = 20 \Rightarrow x = \sqrt{3}$ or $-\sqrt{3}$ ▪ to form and solve exactly equations where the unknown appears in two terms, each of the same power eg $4x - 2 = 2x + 8$, $3x^2 + 4 = 20 - x^2$	.	**c)** Solutions to problems arising from algebraic expressions used to model real world situations involving techniques that include: • simplifying expressions • changing the subject of formulae • solving equations • using simultaneous linear equations. N.B. Students should use understandable algebraic notation and show clearly the stages of their working. (Time for Portfolio work - approx. 10 hours)
Solve Simultaneous Equations (5 hours)	Find the approximate solution of linear simultaneous equations by finding the point of intersection of two straight lines. Form and solve pairs of linear simultaneous equations by an algebraic method.	**Plumbers' Prices** (starter) Introduction to the graphical solution of simultaneous equations using Excel in real contexts. Can be used as a follow-up to Hire a Coach.	
		Circuit Boards (assignment) Students investigate the cost efficiency of two machines using graphical and algebraic techniques. Includes a guidance sheet.	
Solve Quadratic Equations (6 hours)	by • factorising • using the formula $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$	**Factor Cards** (skills activity) Nearly 100 pairs of cards showing a wide variety of quadratic expressions and their factors. Use in a pairing activity to give students practice in expanding brackets or factorising.	
		Quadratic Formula (skills activity) Two examples introducing the quadratic formula and a set of similar equations to solve.	
		Tunnel (skills activity) Students solve a problem involving a road tunnel by finding solutions of quadratic equations using a graph drawn in Excel and then using the quadratic formula. Includes a range of other problems.	
Revision (6 hours)