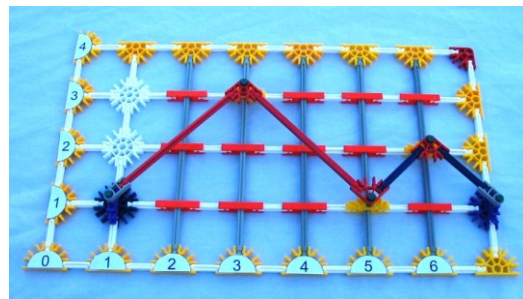
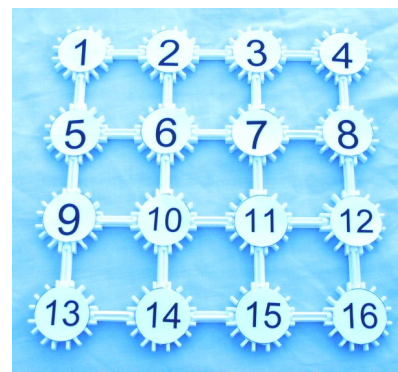
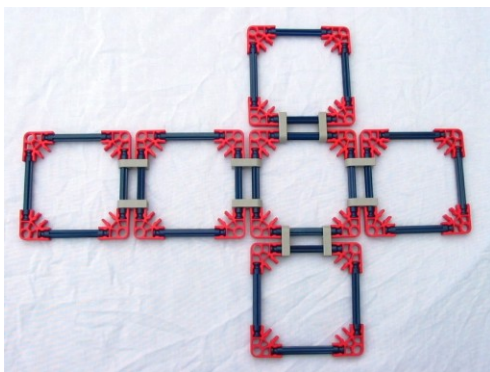




This is the
full version
of the Guide

K'NEX for hands-on Maths

...including 101 hands-on maths activities
with the K'NEX construction kit



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1. Introduction

The K'NEX construction kit has been used successfully in schools and in other forms of education since 1995. Initially, K'NEX was seen just as an innovative and exciting way of helping children understand the Design and Technology curriculum, but increasingly K'NEX has been put to many different uses, including:

- Design and Technology curriculum
- Maths curriculum
- Adult numeracy
- Science curriculum
- Early Years
- Children's clubs
- Childcare schemes
- Family learning
- Home education

All K'NEX sets include instructions for building a range of models, but very few of the sets include any instructions or guidance for using K'NEX in maths activities, despite its many strengths in this area. The purpose of this guide is to rectify this omission, by providing lots of ideas for using K'NEX in:

- Maths curriculum at Key Stages 1, 2, 3 and 4
- Out-of-school maths education (eg maths clubs)
- Adult numeracy curriculum

Note that the Guide does not attempt to explain how to teach maths in these settings, but rather provides a wealth of resources to assist those working in this field. This Guide is available as both a printed Guide, and a PDF version on CDROM. Adobe Acrobat is required to view the Guide on CDROM.

1.1 Who is this guide for?

This Guide has been written for everyone who has an interest in Maths education, including:

- Headteachers
- Teachers
- Adult tutors
- Family learning practitioners
- Children's club leaders and helpers
- Childcare scheme leaders and helpers
- Home educators

1.2 What is K'NEX

K'NEX is one of the most successful construction kits in the world, second in popularity only to Lego. It is based around a series of "rods", which can be joined together by "connectors" such as the one shown in our logo. Once they have mastered using these simple components, children and adults alike can use their imagination to make potentially millions of different models.

It is ease of use and versatility that make K'NEX such a good investment for educational purposes, whether in schools, home education, children's clubs, childcare schemes, family learning or post-16 education. You will find that there is no age limit for enjoying K'NEX - it is suitable for all ages from 5 to 95. There is also a version of K'NEX with bigger components for 3-5 year olds, called Kid K'NEX, as shown in the photo.



Building K'NEX models helps children and adults to understand subjects such as structures, forces, simple machines and maths, in the way that Meccano educated an earlier generation. However, Meccano was aimed and advertised exclusively at boys, whereas both girls and boys find K'NEX easy and enjoyable to use. K'NEX can also be used effectively with adults, once they have mastered the basic techniques for joining rods and connectors together.

It is also worth remembering that even though educational organisations use K'NEX because of its high educational value, children and adults enjoy using K'NEX simply because it is fun. This makes K'NEX a good vehicle for engaging hard-to-reach learners, such as those from deprived areas, those with learning difficulties, and those with behavioural and emotional problems.

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2. K'NEX for hands-on maths

This section gives an overview of the maths skills and knowledge that can be developed with the help of K'NEX activities. The four subsections relate to the main subdivisions of the maths curriculum in schools and in adult education. Section 4 then contains K'NEX activities corresponding to each subsection.

Note that the Guide does not attempt to relate the K'NEX activities to different ages, key stages or levels in the curriculum. Rather, a multitude of K'NEX activities is provided, from which the teacher or tutor can select to suit the needs and abilities of their students.

Note also that, in addition to helping students to gain maths skills and knowledge, K'NEX can also help to deliver the common requirements of the National Curriculum, including:

- Problem-solving skills
- Creative skills
- Communication skills

2.1 Shape and Space

One of the major strengths of K'NEX is that it is a rod-and-connector construction kit based on a consistent and easy-to-understand geometry. The main rods and connectors are shown opposite, and Section 4 shows how:

1. the different lengths of rod relate to each other (Activity 1)
2. the rods and connectors can be used to make five different sizes of right-angled triangle (Activity 3) and six different sizes of K'NEX square (Activity 5)
3. K'NEX squares can always be subdivided into four K'NEX triangles (Activity 10)
4. K'NEX can be used to build cubes and other 3D shapes (Activities 18 to 22)

In getting students started with K'NEX, we would recommend starting with some of the simpler K'NEX shape and space activities, as shown in Section 4.1. These will give an understanding of the geometry and use of K'NEX, and the confidence to progress to more advanced activities.

The activities in Section 4.1 will help students to understand:

- 2D shapes
- 3D shapes
- Similarity
- Angles
- Patterns and relationships
- Translation, rotation and reflection
- Symmetry
- Coordinates
- Scale
- Logo

2.2 Number

Students who are using K'NEX to build models, carry out the activities in this Guide, or to complete K'NEX challenges are applying their maths skills and knowledge constantly. As an example, the completion of any one of the models in the instruction booklet that arrives with a K'NEX set may involve:

1. Interpreting a 2D representation of a 3D model
2. Selecting components by size, shape and colour
3. Counting the number of each component needed
4. Deciding which component to add next
5. Aligning each component so that it will fit into the part-completed model

Once students have become familiar with K'NEX, by building models from instruction books, and completing some of the simpler Shape and Space activities, they can then progress onto Number activities selected from Section 4.2. These activities are designed to help students to understand:

- Counting
- Addition
- Subtraction
- Multiplication
- Division
- Number lines
- Number squares
- Simple fractions
- Money
- Number sequences
- Squares and cubes
- Square and cube roots
- Estimating
- Algebra
- Equations

Note that the activities in Sections 4.1, 4.3 and 4.4 will also help to develop the above number skills.



2.3 Measure

Maths in the National Curriculum and the Adult Numeracy Curriculum both require students to gain a good understanding of “Measure”. The K’NEX activities in Section 4.3 will help provide this, via the following topics:

- Length
- Mass
- Capacity
- Time
- Speed
- Units
- Measuring instruments
- Reading scales
- Perimeter
- Area
- Volume
- Maps, layouts and directions

2.4 Handling data

Students make regular use of computers in developing maths skills and knowledge, for instance by using spreadsheets to develop a knowledge of data handling. However, there is a danger that an over-reliance on computer-based methods can result on students not understanding the basic principles involved. For instance, how a bar chart may be built from data stored in a table.

The K’NEX-based data handling activities in Section 4.4 are designed to complement computer-based work, by giving students hands-on experience in:

- Sorting and classifying
- Collecting data
- Tables
- Diagrams
- Graphs
- Charts
- Mode, median, mean and range
- Probability
- Maths investigations

3. Delivering K’NEX activities

The purpose of this section of the Guide is to provide some general guidance in planning and delivering the K’NEX activities listed in Section 4. Note that the section does not include guidance for specific educational settings. Such guidance may be found in our other K’NEX Guides, which are:

- Guide to using K’NEX in Family Learning
- Guide to using K’NEX in Children’s clubs and Childcare schemes
- Guide to using K’NEX in Primary Schools
- Guide to using K’NEX in Secondary schools
- Guide to using K’NEX in Post-16 education
- Guide to using K’NEX in Home Education
- Guide to using Kid K’NEX with 3-7 year olds

3.1 Becoming familiar with K’NEX

If you do not have any K’NEX at present, it is a good idea to start by purchasing a small K’NEX education set. You can then familiarise yourself with K’NEX, before going on to decide which K’NEX activities to offer.

Appendix C provides an overview of the K’NEX education sets that are most suited to maths activities, and you may like to choose one of the lower cost sets for familiarisation purposes. Once you purchased your set, we recommend that:

- a. you build some of the models in the accompanying instruction book
- b. you look at pages on the User Group website www.knexusergroup.org.uk such as Handy Hints, Instructions and Challenges
- c. You complete some of the simpler maths activities in Section 4.

You might also like to consider attending one of the User Group’s training courses, as shown on the “Training” page of the website.

3.2 Venues and room layout

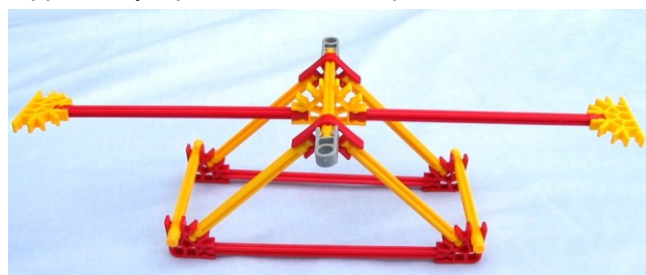
Many venues are suitable for K’NEX maths activities, including:

- Primary schools
- Secondary schools
- Out-of-school clubs
- FE colleges
- Universities
- Adult education centres
- Family learning centres
- Local companies
- Community centres

K’NEX maths activities can easily be carried out in a classroom or similar sized room, or if the numbers participating are too large, in a bigger room such as a school hall.

The relatively small amount of equipment needed for most K’NEX maths activities means that they can be delivered on a whole-class basis. The most common room layout is students seated in fours at tables, with each table sharing a box of K’NEX, and students working in pairs to complete their K’NEX activity.

Activities can also be provided to students on an individual basis, for instance if you are using the activities to test their current level of skills and knowledge. However, working in pairs is to be preferred in most instances, because of the opportunity it provides to develop the use of



mathematical language, and teamworking skills.

Two alternative approaches to working at tables in pairs are:

- Working on the floor in groups of 3 or 4 to complete larger K'NEX activities such as the map of New York City (Activity 80)
- Providing K'NEX activities outdoors in dry, warm weather, such as making a plan of the school grounds using the K'NEX measuring wheel and theodolite (Activity 76).

3.3 Selecting K'NEX maths activities

Section 4 contains 101 K'NEX maths activities, suitable for a wide range of ages and abilities. Some of the factors you may like to consider in selecting maths activities for your own group of students are:

- a. What are your educational objectives?
- b. What level of skills and knowledge do the students already have?
- c. Which activities will best complement the other maths activities you have planned?
- d. Will the challenges be completed on the table-top, on the floor, or outside?
- e. What is the timeslot available for the activity?
- f. Can the activity be completed with only a standard tray of K'NEX components, or does it require special K'NEX components such as gear wheels?
- g. Will the activity require preparation, such as photocopying one of the number sheets in Appendix B (see section 3.5)?
- h. How will you present the activity to the students?

The main alternatives in presenting the activity to the class are:

- Explaining the activity verbally to the class
- Photocopying the relevant page of Section 4
- Printing the page in colour from the CDROM that accompanies this Guide
- Displaying the CDROM page to the class on a data projector and screen

3.4 Buying the K'NEX needed

Once you have become familiar with K'NEX, decided on the venue and room layout for your maths activities, and chosen the activities to offer, you will be in a position to buy the K'NEX needed.

The basic requirement will usually be a sturdy plastic compartmented tray, containing a good selection of all the basic K'NEX rods and connectors, for each group of 4 students. All the sets listed in Appendix C will provide this, although the larger sets contain a higher number of K'NEX components in each tray.

Depending on the K'NEX maths activities you have chosen, you may also need:

- Number sheets photocopied from Appendix B.
- Any extra materials needed to complete the activity, such as white card, or a plastic carrier bag.
- Special K'NEX components, such as gear wheels (see photo below).

All the sets can be purchased either by:

1. Faxing or mailing us a written purchase order (using the form in Appendix C or your organisation's usual purchase order form), or
2. Buying the K'NEX sets by credit card or invoice via the on-line shop in our website www.knexusergroup.org.uk

If you are buying K'NEX to be used as a central resource in your school or educational establishment (rather than just as a maths resource), or if you want to buy sets that include special components such as gears, you may also find it useful to look at the full range of K'NEX education sets in the on-line shop.

3.5 Number sheets

Some of the K'NEX maths activities in this Guide require that numbers are affixed to K'NEX connectors. For example, to label the axes in a bar chart. Appendix B includes "Number sheets" for the most commonly used numbers and styles. These sheets should be printed out on thin card, laminated (if possible) and attached to the relevant K'NEX connector with Bluetac (or similar).

3.6 And finally...

Once you have used a number of the K'NEX maths activities in Section 4, you may like to develop your own activities. K'NEX is very versatile, and there is the potential to develop 1001 K'NEX maths activities, not just the 101 listed in this Guide.

Good luck! And please email us:

- If you have any queries or suggestions on the K'NEX maths activities in Section 4.
- If you need any help choosing the most appropriate K'NEX education sets
- If you have any ideas for improvements to this Guide.



Section 4 – 101 K’NEX Maths activities

This Section contains 101 K’NEX maths activities. The subsections correspond to the subsections in section 2. The printed version of the Guide contains only one or two small photos for each activity. The CDROM version contains larger images, and extra photos for some of the activities. The Appendix contents are as follows:

4.1 Shape and Space

2D activities from instructions:

1. K’NEX rods
2. K’NEX connectors
3. Five sizes of K’NEX triangle
4. Learning about triangles
5. Six sizes of K’NEX square
6. Rectangle
7. Rhombus
8. Trapezoid
9. Octagon
10. Filling in 2D K’NEX shapes
11. Eight-pointed star
12. Translation, rotation and reflection
13. 2D symmetry
14. Coordinates
15. Logo
16. Pantograph

3D activities from instructions:

17. Building 3D shapes with K’NEX
18. Cube
19. Cuboid
20. Pyramid
21. Prism
22. Nets
23. 3D symmetry

Activities that are K’NEX challenges:

24. K’NEX picture
25. K’NEX maze
26. K’NEX alphabet
27. K’NEX drawing aids
28. K’NEX ferris wheel

4.2 Number

Activities from instructions:

29. Sorting by shape, size and colour
30. Counting rods and connectors
31. Counting shapes
32. K’NEX numerals
33. Number square
34. Number line
35. Money line
36. Simple scales

37. Scales with multiple positions
38. Costing with K’NEX
39. Maths investigation - gear ratios
40. Learning about fractions
41. Learning about squares, cubes and roots
42. Abacus
43. Learning about number sequences
44. Estimating with K’NEX
45. Algebra with K’NEX

Activities that are games:

46. Pick-a-rod
 47. Colour game
 48. Dominoes
 49. 3s and 5s spider’s web
 50. Draughts
 51. Darts
 52. Ten-pin skittles
 53. Wheel roll
 54. Number box
 55. Tower of Hanoi
- #### Activities that are K’NEX challenges:
56. Costed bridge
 57. Costed desk tidy
 58. Shopping trolley game
 59. Ludo-like game

4.3 Measure

Activities from instructions:

60. Learning about area and perimeter
61. Learning about volume
62. Ruler
63. Pair of compasses
64. Calipers
65. Measuring wheel
66. Water tank
67. Weighing scales
68. Crane
69. Pendulum
70. Clock face
71. Analogue clock
72. Digital clock
73. Sundial

74. Speed investigation - ramp
 75. Speed investigation - pendulum
 76. Theodolite
 77. Level or sextant
- #### Activities that are games:
78. Timed challenge
- #### Activities that are K’NEX challenges:
79. Rubber band scales
 80. Map of New York City
 81. Moon base

4.4 Handling data

Activities from instructions:

82. Organisation chart
83. Flow chart
84. Data table
85. Bar chart
86. Line graph
87. Spreadsheet
88. Pick-a-connector
89. Dice
90. Four-sided Spinner
91. Number pointer
92. Horse-racing pointer
93. Probability line
94. Learning about mean, median, mode, range
95. Coding machine

Activities that are games:

96. Predictions
97. Horse-racing game

Activities that are K’NEX challenges:

98. Premiership table
99. School dinners
100. Dice with more than six sides
101. Spinner with more than four sides

4.1 Shape and Space

All the activities in this subsection relate to shape and measure.

4.1.1 2D activities from instructions

The activities below use only 2-dimensional (2D) K'NEX shapes.

1. K'NEX rods

K'NEX sets come with a limited number of the longer rods, but you can always join two shorter rods together if you run out of the longer ones.



Join two green rods, two white rods, two blue rods and two yellow rods together as shown below, to prove it for yourself.

2. K'NEX connectors

All K'NEX connectors can be connected to at least one K'NEX rod, and the largest can be connected to eight rods. To help gain familiarity with K'NEX connectors, make the model shown below.



The angle between any two adjacent rods connected to a connector is 45° . This makes K'NEX very good for making shapes that have angles of 45° , 90° and 135° , such as squares, rectangles, right-angled triangles and octagons, as you will see in the next few Activities.

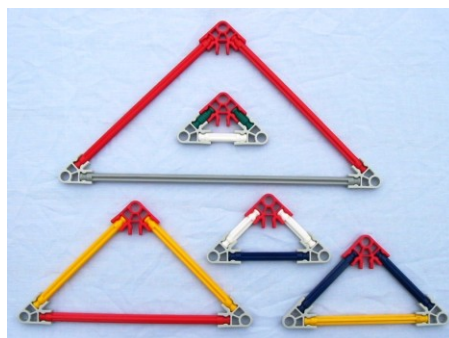


If you need to make an angle other than 45° , 90° or 135° in K'NEX, you can often do this with a K'NEX hinge connector, shown above.

3. Five sizes of K'NEX triangle

The length of the K'NEX rods have been carefully chosen so that, whichever rod you use to make the longest side of a right-angled triangle, the other two sides will require the next-smallest rod.

Try this for yourself, and make the five triangles shown below.



4. Learning about triangles

The triangles above are called right-angled triangles, because they all include one “right-angle”. A right-angle is 90° . Both the other angles in each K'NEX triangle above are 45° .

As you can see, the three angles (90° , 45° and 45°) add up to 180° , and indeed the three angles of any triangle always add up to 180° .

As well as making right-angled triangles using the standard K'NEX connectors, you can also use hinges to make triangles. Try the one below.



Some triangles have special names:

An “equilateral triangle” has three sides of equal length.

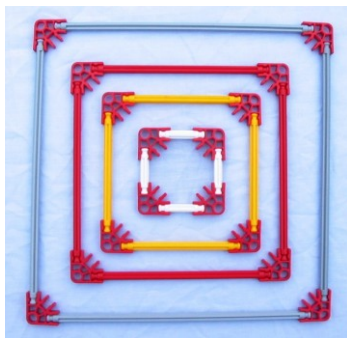
An “isosceles triangle” has only two sides of equal length.

Q1. Which of the triangles you made in this Activity and in Activity 3 are equilateral triangles, and which are isosceles triangles?

Q2. Can you calculate the size of the three equal angles in the equilateral triangle?

5. Six sizes of K'NEX square

A square has four sides of equal length, and all the angles are right-angles. Can you make the four different-sized K'NEX squares below?



Q1. Can you make two other sizes of K'NEX squares?

Shapes are said to be “similar” if they are the same shape, but a different size. All the squares above are similar.

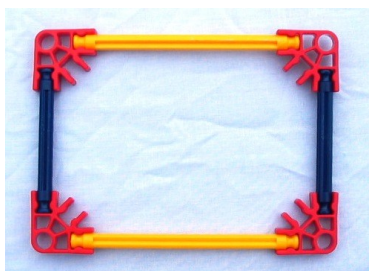
Q2. Do similar shapes have the same length sides?

Q3. Do similar shapes have the same angles?

Q4. Are the triangles in Activity 3 similar?

6. Rectangle

A rectangle has right-angles like a square, but two of the sides are longer than the other two sides. Build the K'NEX rectangle shown below.

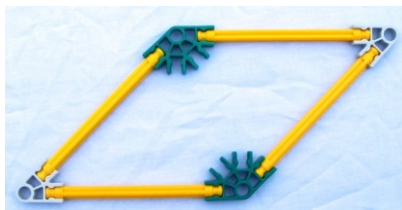


Q1. Can you build three other sizes of rectangle?

7. Rhombus

In squares and rectangles, the sides are said to be “parallel”, because they run in the same direction. The easiest way to test if two lines are parallel is to extend them in both directions. If they lines eventually meet, then they are not parallel – you can extend parallel lines for ever, and they will still not meet.

A four-sided shape with two sets of parallel sides of equal length is called a rhombus. Build the one shown below.



Q1. What are the angles in the above rhombus?

Q2. Can you use four hinges to make a rhombus which has different angles?

8. Trapezoid

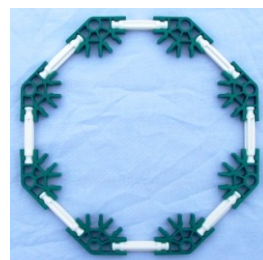
It is also possible to make a four-sided shape which has two sides that are parallel, and two sides that are not parallel. Any four-sided shape with only 2 parallel sides is called a “Trapezoid”. Build the one below.



Q1. What are the four angles in the above trapezoid?

9. Octagon

An eight-sided shape is called an “Octagon”. Build the one below.

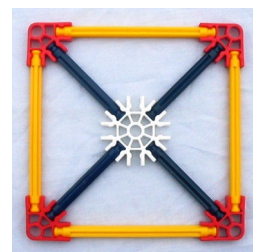


Q1. The eight angles in the above octagon are all the same. What angle are they?

Q2. Can you build an K'NEX octagon in which not all sides and angles are the same?

10. Filling in 2D K'NEX shapes

Most 2D K'NEX shapes can be “filled in”, with triangles, squares, etc. Build the K'NEX square below, and fill it in with triangles as shown.

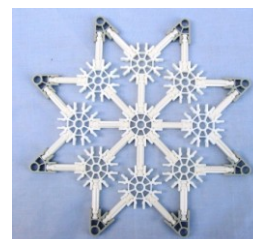


Q1. Which of the other shapes in Activities 3 to 9 can be filled in just with triangles?

Q2. Which shapes can be filled in with a combination of triangles and squares?

11. Eight-pointed star

You can make many other two-dimensional shapes out of K'NEX. Build the eight-pointed star below.



Q1. What different angles can you find in the above star?

12. Translation, rotation and reflection

Make the K'NEX letter "E" shown below, and place it on the table or desk in front of you.

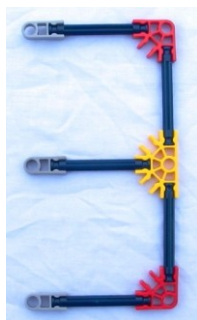
Now experiment by moving it around. You will find there are three ways of moving it:

"Translation" – where you slide the shape across the table, still in the upright letter "E" position.

"Rotation" – where you turn (or rotate) the letter "E".



"Reflection" – where you pick up the letter, turn it over, and put it down again. This is called "reflection", because what you end up with is the same as a reflection of the shape in a mirror.



Many computer-based drawing packages allow you to apply translation, rotation and reflection to a shape, though "reflection" is often referred to as "flip".

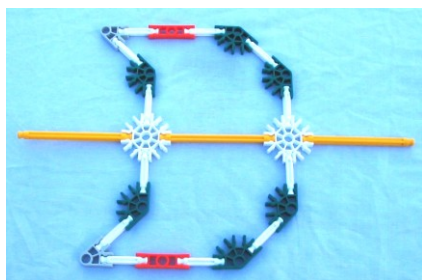
Q1. Can you make a numeral "2" and flip it to become the numeral "5"?

Q2. Which other letters or numerals turn into a different letter or numeral when they are rotated or flipped?

13. 2D symmetry

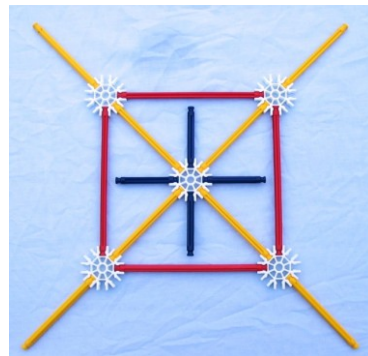
Extra equipment: Mirror

Build the K'NEX shape below.



This shape is "symmetrical", because the part of the shape above the horizontal yellow line is a mirror image of the part of the shape below the horizontal yellow line. You can confirm this by placing a rectangular mirror upright along the yellow line. The yellow line is called a "line of symmetry".

Now build the K'NEX shape below.



Two of the lines of symmetry in this shape are highlighted with yellow rods.

Q1. Can you find more than two lines of symmetry in the picture above?

Q2. Are the shapes in Activities 3 to 11 symmetrical?

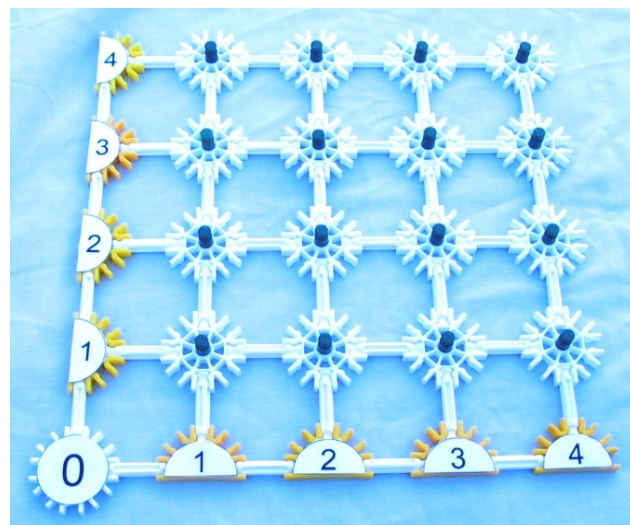
Q3. How many lines of symmetry does each shape possess?

Q4. Can you show each line of symmetry by adding yellow rods?

14. Coordinates

Extra equipment: Numerals from Appendix B

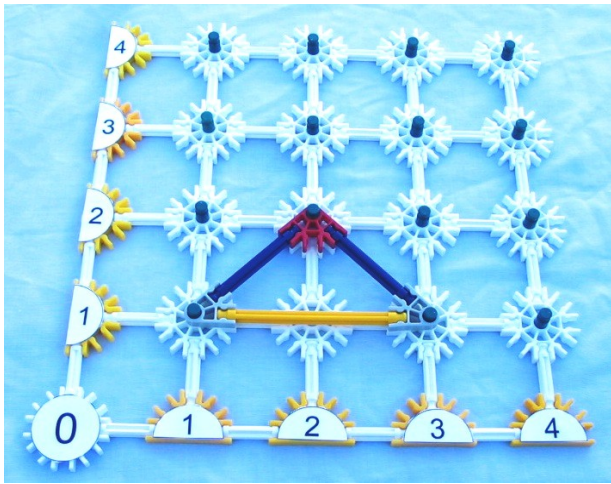
Build the K'NEX grid shown below, and attach the numerals with Bluetac or similar.



The numerals up the left hand side are known as the "x axis", and number the horizontal lines. The numerals across the bottom are known as the "y axis", and number the vertical lines. At every intersection of a horizontal line and a vertical line there is a white connector and a green rod.

Each white connector has a "coordinate" (x,y) which is the number of the horizontal line, followed by the number of the vertical line.

Now build a K'NEX triangle with its corners at (1,1), (2,2) and (1,3), as shown.

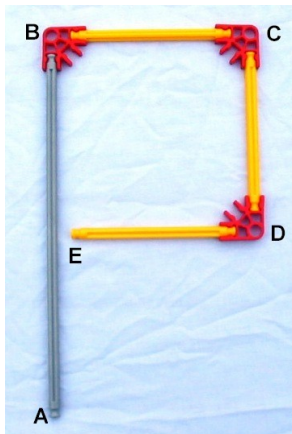


Q1. What shape would yet you get if you build a K'NEX model with its corners at (3,1), (3,4), (1,1) and (1,4)?

Q2. Make a triangle with two yellow rods and a red rod. Place it on the grid, with the right angled corner on coordinate (1,0). Then write down the coordinate of the other two corners of the triangle.

15. Logo

The coordinates in Activity 14 provide one way of specifying "instructions" to build a K'NEX model. Another way of providing instructions is via the language "Logo".



The Logo commands for the letter "P" shown below, starting at point A, are:

- Forward 190 (ie 190mm - one grey rod).
- Right 90 (ie 90 degrees).
- Forward 85 (ie 85mm – one yellow rod)
- Right 90
- Forward 85
- Right 90
- Forward 85

Pencil

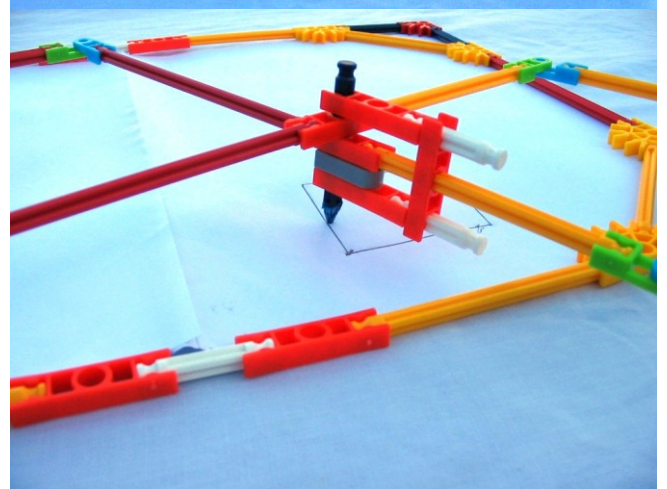
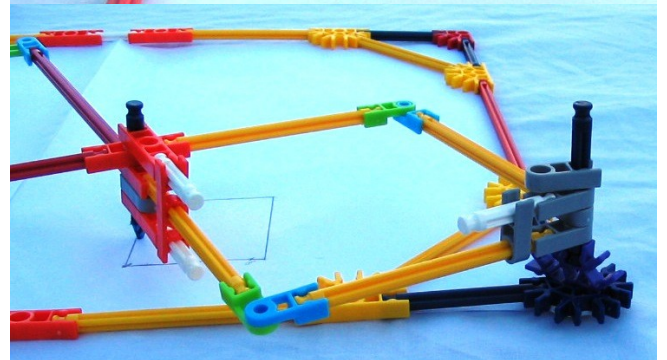
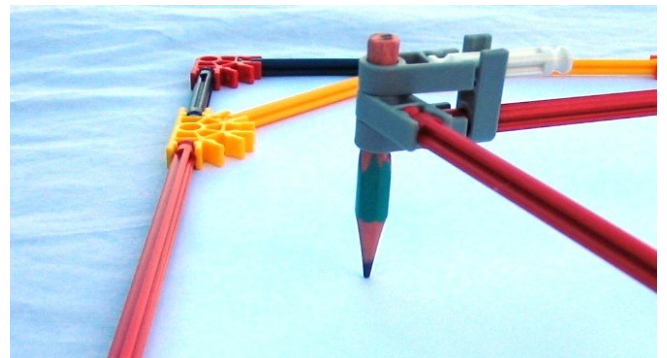
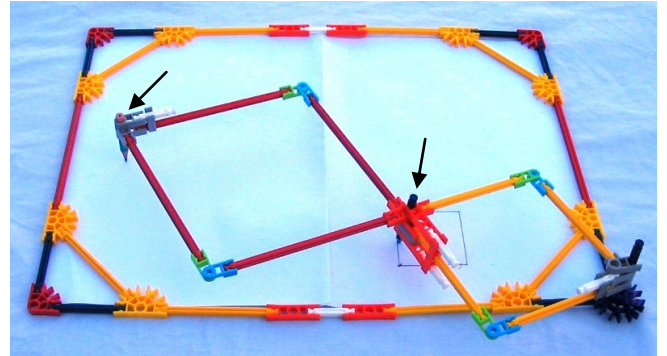
Pointer

Q1. What Logo commands are required to make the letters "M" and "N"?

16. Pantograph

Extra equipment: pointer, short pencil

Activities 3 and 5 showed how K'NEX triangles and squares can be built in different sizes. A "pantograph" is a simple device for copying drawings, to make them bigger or smaller. Build the K'NEX pantograph below.



The pointer shown in the photo can be made by sharpening a blue K'NEX rod with a pencil sharpener until it has a blunt point.

Next, find a sheet of A3 paper, or make one by joining together two sheets of A4 paper. Draw a square on the paper with sides 4cm long, as shown. Attach the fixed leg of the pantograph to the bottom left hand corner of the paper. Then trace over the square with the pointer with one hand, whilst at the same time pressing down on the pencil with your other hand. You will see a square appear, but larger than the original.

Q1. What length of side does the new square have?

The new square is a different size because the pantograph has yellow rods between the fixed leg and pointer, but red rods between the pointer and pencil.

Q2. What will happen if you replace the four red rods with yellow rods, and copy the square again?

Q3. What will happen if you replace the four red rods with blue rods, and copy the square again?

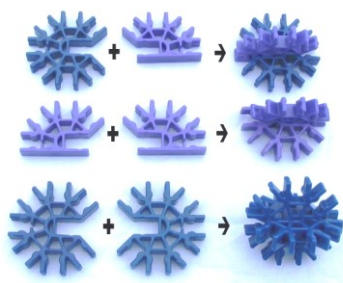
Q4. Can you use your pantograph to copy a simple line drawing out of a book (eg Winnie the Pooh)?

4.1.2 3D activities from instructions

The activities below use 3-dimensional (3D) K'NEX shapes.

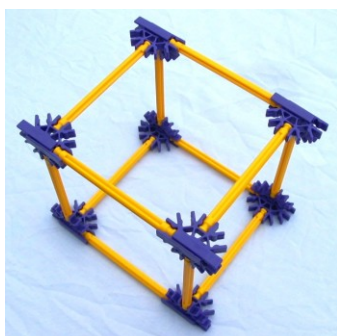
17. Building 3D shapes with K'NEX

K'NEX is also very good for building 3D K'NEX shapes. The blue and the purple connectors are specially designed to be joined together when building 3D shapes. Follow the instructions below to see how to join them together.



18. Cube

A cube is a 3D shape in which all 12 faces are of equal length. Build the cube below.



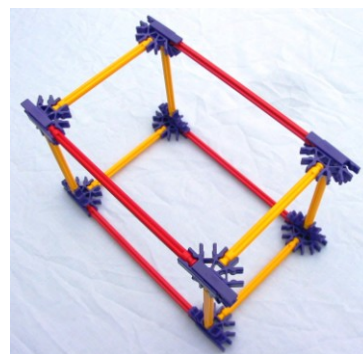
Q1. How many faces does a cube have?

Q2. What shape is each face?

Q3. Can you build a cube using only blue rods?

19. Cuboid

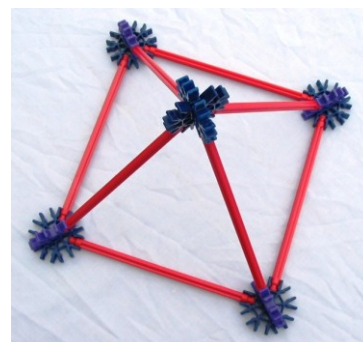
A cuboid is a shape in which the faces are two squares and four rectangles. Build the cuboid shown below:



Q1. Can you build a cuboid using only blue rods and yellow rods?

20. Pyramid

Build the pyramid shown below.

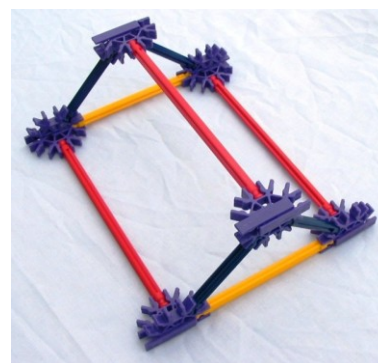


Q1. What shape is the base of the pyramid?

Q2. What shape are the other faces of the pyramid?

21. Prism

Build the prism shown below.



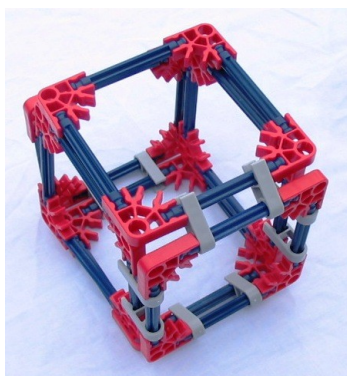
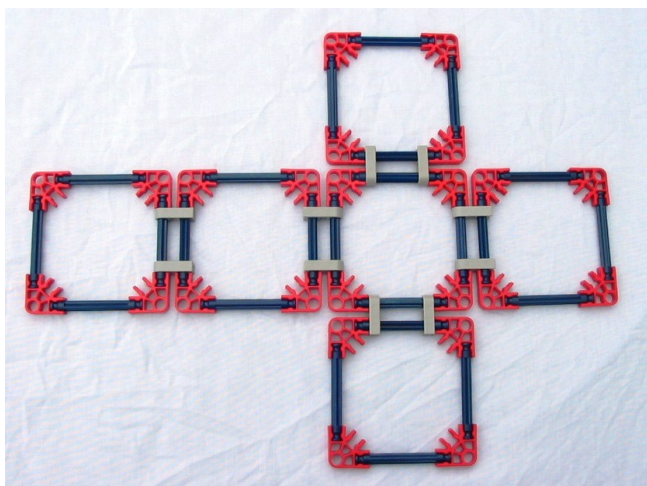
Q1. What shape are the ends of the prism?

Q2. What shape are the other faces of the prism?

22. Nets

Simple 3D shapes can be built by folding up a "net", which includes every side of the 3D shape.

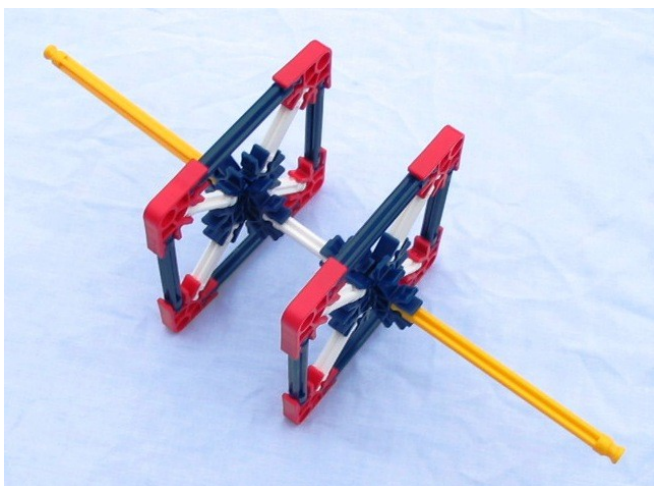
Make a net for a cube as shown below, and fold it up into a cube.



Q1. Can you make a net for a cuboid, a pyramid and a prism?

23. 3D symmetry

Activity 13 explained how to identify lines of symmetry in 2D K'NEX models. Build the model below to demonstrate how 3D models can also have lines of symmetry.



Q1. How many lines of symmetry have the cube, cuboid, pyramid and prism in Activities 18 to 21?

Q2. Can you add yellow K'NEX rods to indicate the lines of symmetry for each shape?

4.1.3 K'NEX challenges

All the Activities below are K'NEX "challenges", for which no instructions are required. It is recommended that students complete some of the 2D and 3D Activities earlier in this section before attempting any of these challenges.

24. K'NEX picture

Q1. Can you make a K'NEX picture in a frame, to hang on the wall? It can either be a picture of a real-life object, or simply a pattern made up from triangles, squares and other shapes.

25. K'NEX maze

Q1. Can you use K'NEX to build a maze, with:

- One entry point
- One finishing point at the centre
- Only one way to get from the starting point to the finishing point
- Lots of ways to get lost!

Q2. Can you use Logo to write down directions for completing the maze (see Activity 15).

26. K'NEX alphabet

Q1. Can you use K'NEX to make an alphabet, and then use the letters to spell your name?

27. K'NEX drawing aids

Extra equipment: K'NEX wheel without a tyre

Q1. Can you make K'NEX drawing aids, that will enable you to draw on a piece of paper:

- A straight line
- A second line at an angle of 90° to the first line
- A third line at an angle of 45° to the first line
- A circle

Q2. Can you use the drawing aids to draw a design for a simple wheeled vehicle, such as a shopping trolley or baby buggy?

28. K'NEX ferris wheel

Build a Ferris Wheel out of K'NEX

When you have finished:

Q1. Identify and count the 2D shapes used in your Ferris Wheel (triangles, squares, etc).

Q2. Identify any congruent shapes used.

Q3. Identify and count the 3D shapes used in your Ferris Wheel (cubes, etc).

Q4. Identify and count the angles used in your Ferris Wheel.

Q5. Work out how many lines of symmetry the wheel in your Ferris Wheel has.

4.2 Number

All the activities in this subsection relate to number. The questions shown against each Activity are only examples – you may wish to think up your own questions for each activity, that best suit the ability and experience of your students.

Note that most of the activities in subsections 4.1, 4.3 and 4.4 will also help students to develop number skills.

4.2.1 Activities from instructions

The activities below can be completed from the instructions provided.

29. Sorting by shape, size and colour

Find one each of the K'NEX connectors shown in the photo below.



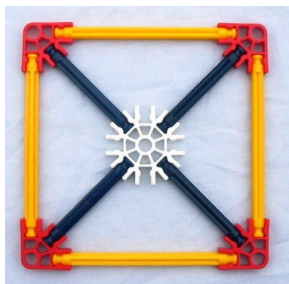
Q1. Connect as many rods as you can to each connector. Write down the number of rods that each connector can connect to.

30. Counting rods and connectors

Count out:

- 4 yellow rods
- 4 blue rods
- 4 red connectors
- 1 white connector

and use them to make the shape below.



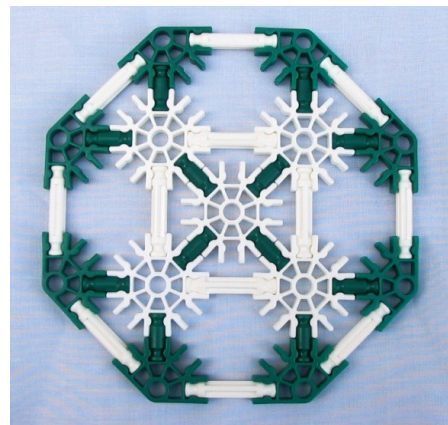
Q1. Can you make one of the models in the instruction book that came with your K'NEX set, by counting out the pieces, and then using them to build the model?

31. Counting shapes

Count out:

- 12 white rods
- 12 green rods
- 8 green connectors
- 5 white connectors

and use them to make the shape below.



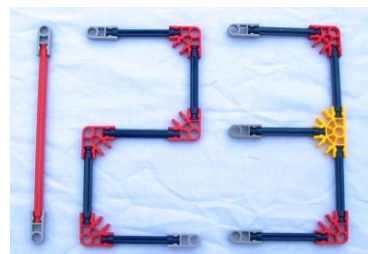
Q1. How many triangles can you find in this shape?

Q2. How many squares can you find in this shape?

Q3. How many rectangles can you find in this shape?

32. K'NEX numerals

Make the K'NEX numerals in the photo below.



Q1. Can you make the numerals 4, 5, 6, 7, 8, 9 and zero?

Q2. Can you show your age in K'NEX numerals?

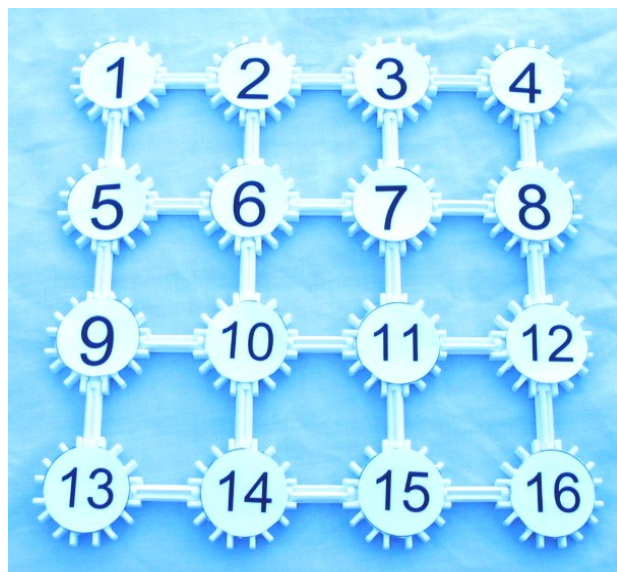
Q3. Can you use the numerals to write down today's date, in the format dd/mm/yy, where the "/" symbol is a grey rod?

Q4. Can you use the numerals to write down the time in digital clock format, in the format hh:mm, where the ":" symbol is two tan connectors?

33. Number square

Extra equipment: Numerals from Appendix B

Make the four-by-four number square shown below:



Q1. Can you use the number square to find 4×2 , 4×3 and 4×4 ?

Q2. Can you make a number square which is 5×5 ?

Q3. Can you make a number square which is 10×10 ?

34. Number line

Extra equipment: Numerals from Appendix B

Make the number line shown below.



Q1. Can you use the number line to work out: $1+3$, $3+4$, $8-2$ and $7-5$?

Now make a number line with zero and with negative numbers, as shown below.



Q2. Can you use this number line to work out: $3-3$, $4-6$ and $-2+4$?

35. Money line

Extra equipment: Numerals from Appendix B

Make the "money line" shown below.



Q1. By placing orange connectors onto the number line, can you make a total of 37p, and then £1.61?

36. Simple scales

Make the scales shown below.

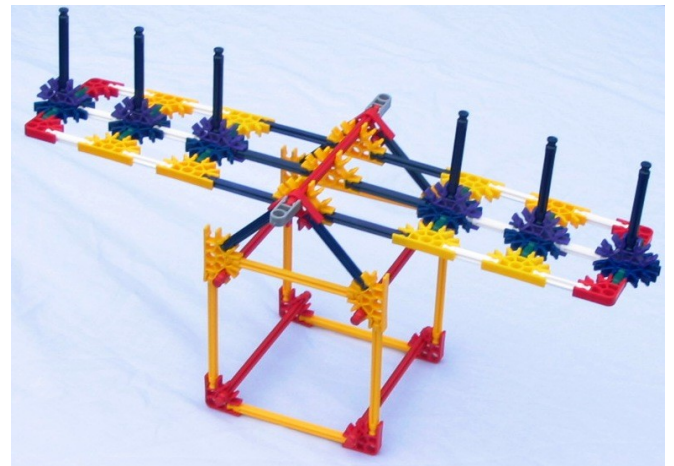


Q1. If you put three white connectors on one side of the scales, how many white connectors will you need to put on the other side to make the scales balance?

Q2. If you put two white connectors on one side of the scales, how many grey connectors will you need to put on the other side to make the scales balance?

37. Scales with multiple positions

Make the scales shown below:

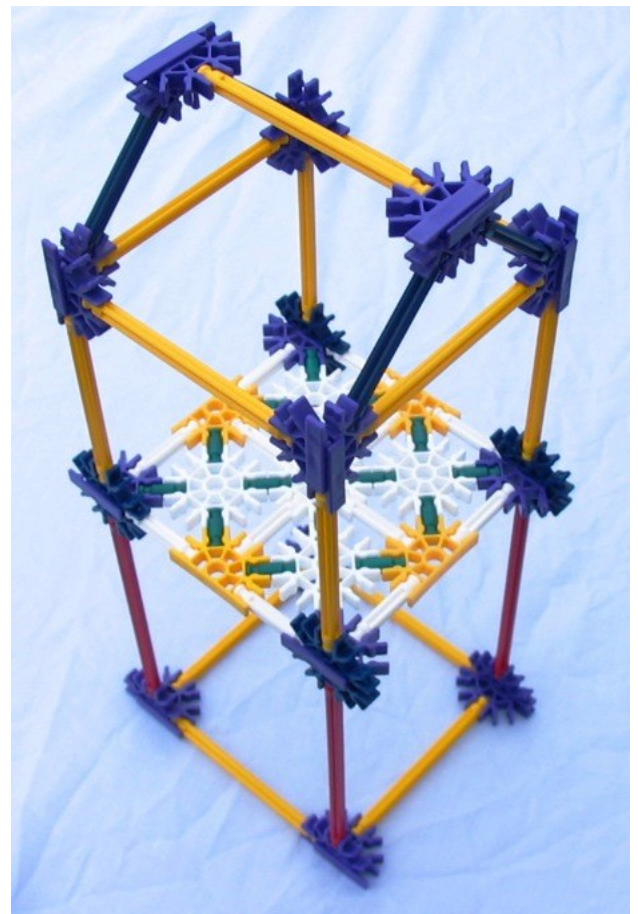


Q1. If you put three white connectors on the innermost position on one side of the scales, how many grey connectors do you need to balance them, and where should they be placed?

Q2. If you put three white connectors on the central position on one side of the scales, how many grey connectors do you need to balance them, and where should they be placed?

38. Costing with K'NEX

Make the K'NEX bird table shown below:



Q1. If each rod costs 5p, and each connector costs 10p, what is the total cost of the bird table?

Q2. Can you design and build a bird table that is only half the cost of the one shown?

39. Maths investigation – gear ratios

Extra equipment: Small and medium-sized gear wheel

Make the K’NEX fan shown below:

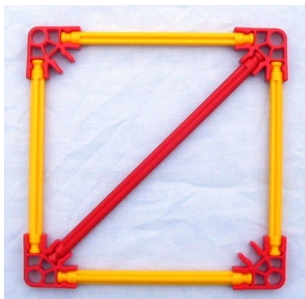


Q1. Count how many times the fan turns for a 360° turn of the handle. This is called the “gear ratio”.

Q2. Can you work out how the two gear wheels provide this gear ratio?

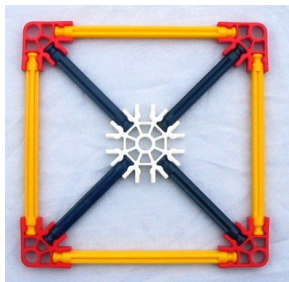
40. Learning about fractions

Make the shape shown below, which is a square containing two triangles:



Q1. Is each triangle $\frac{1}{2}$, $\frac{1}{4}$ or $\frac{3}{4}$ of the area of the square?

Now make the shape below, which is a square containing four triangles.



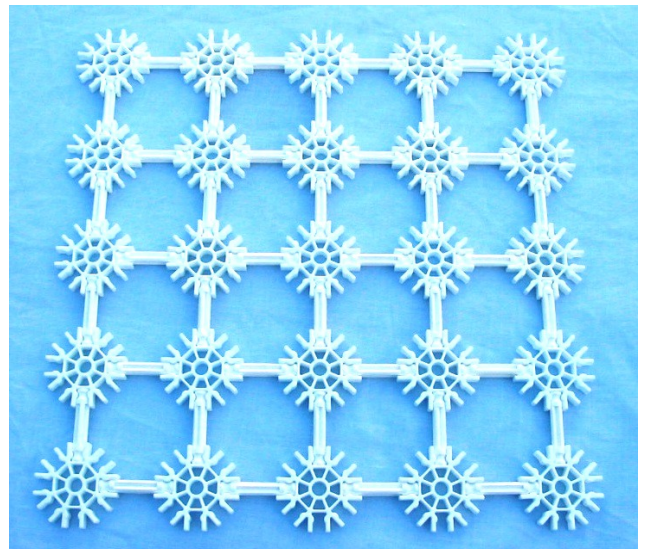
Q2. Is each triangle $\frac{1}{2}$, $\frac{1}{4}$ or $\frac{3}{4}$ of the area of the square?

Q3. Can you build a shape which contains a triangle that is $\frac{1}{8^{\text{th}}}$ of the total area?

Q4. Can you build a shape which contains a triangle that is $\frac{3}{8^{\text{th}}}$ of the total area?

41. Learning about squares, cubes and roots

Make the K’NEX square shown below:



Q1. How many smaller squares are contained in the large square?

You can find the answer either by:

- counting the small squares, or
- multiplying the number of squares wide by the number of squares high

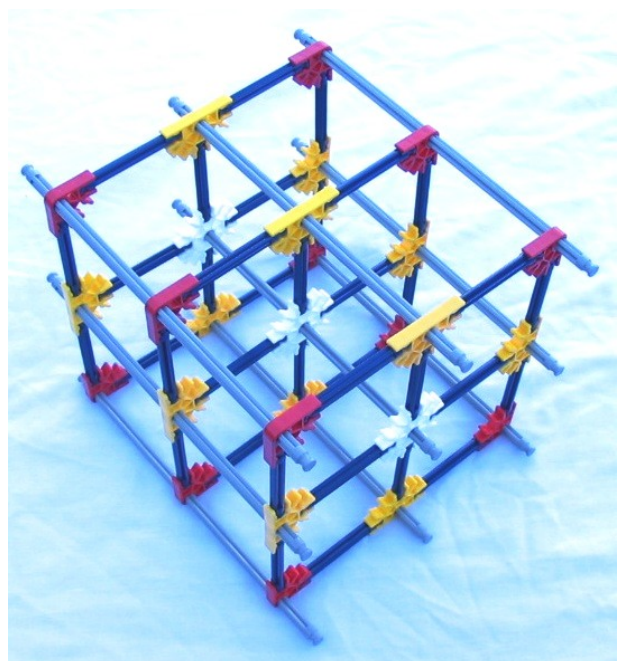
The above shape is 4 squares wide and 4 squares high, so the total number of squares is $4 \times 4 = 16$. Another way of writing this is “4 squared = 16”, or “ $4^2 = 16$ ”.

Q2. Build a shape that is six squares wide and six squares high, and use it to find 6^2

Q3. If you made a large square out of K’NEX that contained 49 small squares, how many squares wide would it be?

Another way of expressing this question is “What is the square root of 49?”.

Now make the K’NEX cube below:



The larger cube contains 8 small cubes, and is 2 cubes high, 2 cubes long and 2 cubes wide. This can be expressed as "2 cubed = 8" or " $2^3 = 8$ ".

Q4. How many small cubes would a large cube contain if it was 3 cubes high, 3 cubes long and 3 cubes wide? I.e, what is 3^3 ?

Q5. If a large cube contained 64 small cubes, how many cubes wide would it be?

Another way of expressing this question is "What is the cube root of 64?".

42. Abacus

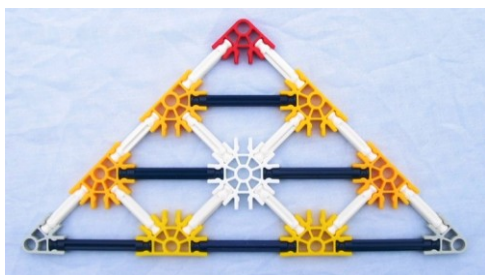
The abacus has been used for thousand of years as a device for carrying out numerical calculations very quickly. Build the abacus shown below.



Now search for some instructions for using your K'NEX abacus on the internet.

43. Learning about number sequences

Make the shape shown below:



If you look at each row in this shape, you will find:

- 1 triangle in the first row
- 3 triangles in the second row
- 5 triangles in the third row

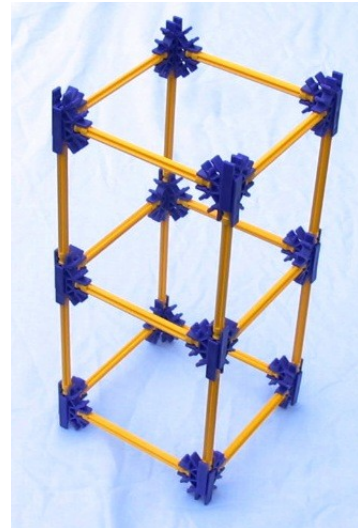
Q1. Add a fourth row of triangles below the shape. How many triangles does it contain?

Another way of asking this question is:

Q2. What is the next number in the sequence 1,3,5....?

44. Estimating with K'NEX

Build the two-level tower shown below:



Q1. How many yellow rods and double-purple connectors would you need to add a third level to the tower?

Now build the tower to check whether you were right. The process of thinking how many extra rods and connectors are needed is called "estimating".

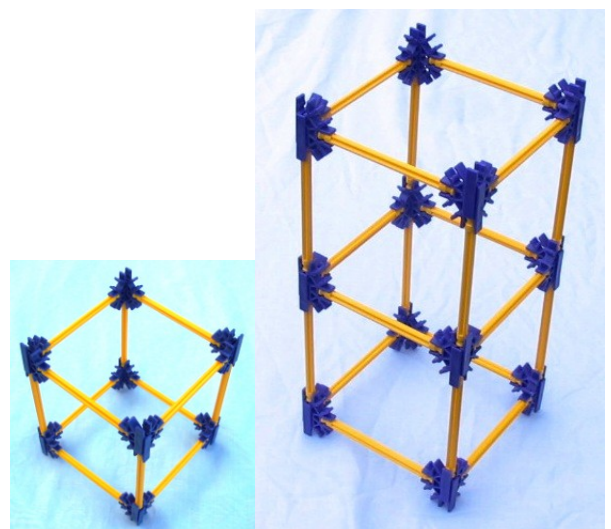
Q2. Estimate how many blue rods and white connectors you would need to build a large K'NEX square which contains 9 smaller squares.

Q3. Estimate how many of each rod and connector you would need to build a roundabout.

Check your estimates by building the models, and counting the rods and connectors you have used.

45. Algebra with K'NEX

Build the one-level tower and then the two-level tower shown below:



The one-level tower requires 12 yellow rods and 8 double-purple connectors. The two-level tower requires 20 yellow rods and 12 double-purple connectors. Adding a third level to the tower would require a further 8 yellow rods and 4 double-purple connectors.

Another way to write this down is as a “formula”:

One-level tower: $12Y + 8P$

Two-level tower: $20Y + 12P$

Three-level tower: $28Y + 16P$

where Y = Number of yellow rods and P = Number of double-purple connectors.

Q1. Can you write down the formula for a four-level and a five-level tower?

Q2. If L is the number of levels in a tower, can you write down the formula which is true for a tower with any number of levels?

K’NEX can also be used to help students understand the concept of equations. For example:

Q3. Can you express the answer to Q2 in Activity 37 (Scales with multiple positions) as an equation, in which [Weight on left] x [distance from pivot] = [Weight on right] x [distance from pivot]?

4.2.2 Activities that are games

The activities below are all games that will help develop number skills.

46. Pick-a-rod

For 2 to 4 players

Put 10 red rods and 10 yellow rods into a box, and then turn the box upside down to create a pile of rods on the tabletop.



The first player tries to take a rod from the pile. If he/she manages to do so without any of the other rods moving, the player keeps the rod, and the player tries to take another rod. As soon as the player causes a rod to move other than the one being taken, he/she must let go of the rod being taken. Play then passes on to the next player, and so on, until all rods have been taken. Players then count up their rods to see who has won.

You should determine your own scoring system according to the numeracy skill level of the players. For instance, score 9 points for a red rod and 6 for a yellow rod.

After playing the game a few times, you might ask your students to come up with a variation on the rules, for instance by including different numbers and

lengths of rod, or introducing K’NEX connectors into the game.

47. Colour game

For 2 to 6 players

Give each player a white connector with eight blue rods attached to it. The object of the game is to add eight different connectors to the ends of the rods, as shown below. The first player to achieve this wins the game.



Put into a bag one of each of the above eight connectors for every player (eg if 4 players, put in 4 of each of the eight connectors). Players then take turns to take a connector out of the bag. If they don’t already have the connector taken out of the bag, they add it onto the end of a rod. If they do already have it, they put the connector back in the bag.

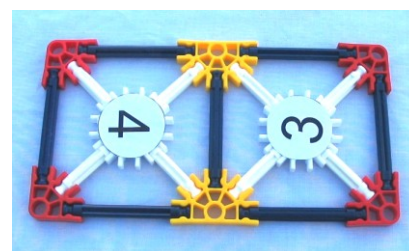
Note that this is designed as very easy game for younger children, because after a bit of practice they will be able to find the connector they want inside the bag by the feel of its shape.

48. Dominoes

For 2 to 4 players

Extra equipment: Numerals from Appendix B

Make a set of dominoes to the design shown below, and then add printed numerals to create the dominoes 1:1, 1:2, 1:3, 1:4, 1:5, 1:6, 2:2, 2:3, 2:4, 2:5, 2:6, 3:3, 3:4, 3:5, 3:6, 4:4, 4:5, 4:6, 5:5, 5:6, 6:6.



Use the dominoes to play a game of dominoes, in which players add a domino with matching numeral to either end of the line, until the first player uses up their last domino.

You can also search for variations on the game of dominoes on the internet. There are many of them, all of which require number skills to a greater or lesser degree.

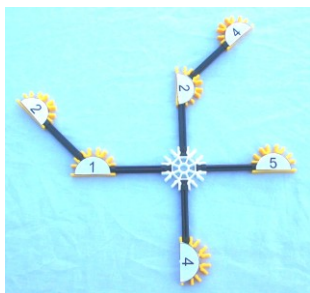
49. 3s and 5s spider’s web

For 2 to 4 players

Extra equipment: Numerals from Appendix B

Affix the numerals from 1 to 5 to a series of yellow connectors. Shake the connectors up in a box, and then deal them out face down so that each player has the same number of pieces. Also put a box of K'NEX on the table, containing an assortment of rods, and a white connector on the table as a starting point for the spider's web.

The players take it in turn to add a rod and a yellow connector to the spider's web, attached either to the white connector, or to any other yellow connector already added to the spider's web.



After attaching their yellow connector and rod, the player adds up the total on all the yellow connectors that have only one rod attached to them. If the total adds up to a multiple of 3 or 5, the player scores the divisor of that total. For instance, score 3 if the total is 9 (3×3), or score 4 if the total is 20 (5×4). If the total is a multiple of both 3 and 5, score the sum of both divisors (eg 15 scores $3 + 5$, as it is both 3×5 and 5×3). Sounds complicated, but it is actually very simple!

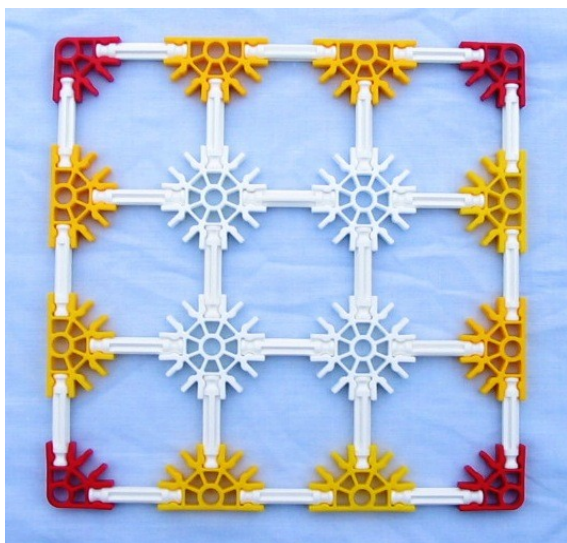
For students for whom determining multiples of 3 and 5 would be too difficult, introduce different rules (eg score a point after each turn if the total is an even number).

After the students have played the game a few times, suggest that they invent their own rules for the game.

50. Draughts

For 2 players

Build an 8-by-8 draught board using the small-square design shown below.



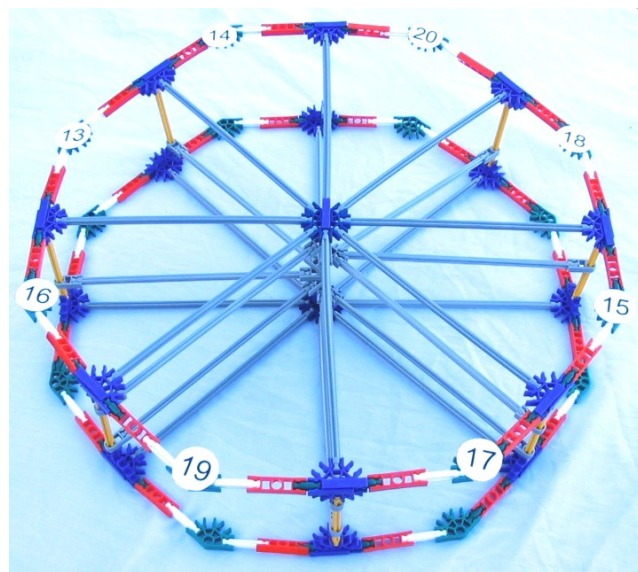
Then play a game of draughts, using 16 white connectors and 16 blue connectors as pieces.

51. Darts

For 2-4 players

Extra equipment: Numerals from Appendix B

Build the dart board shown below, and hang it on the wall so that the centre of the dart boards is at eye height for the players.



Ask each player to make three paper planes from a sheet of A5 paper, with a design which ensures that, when thrown, each dart will lodge in the dartboard. Also draw a line on the floor, which the players will need to stand behind when throwing their darts. You

will need to experiment to find the best distance between the board and the line – perhaps 1 to 3 metres.

Players then take turns to throw their three “darts” at the dart board.

You should adopt a scoring method that is best suited to the number skills of the players. For instance, each player starts with 301, and the score each turn is subtracted from the total. The first player to reach zero (or below) wins the game.

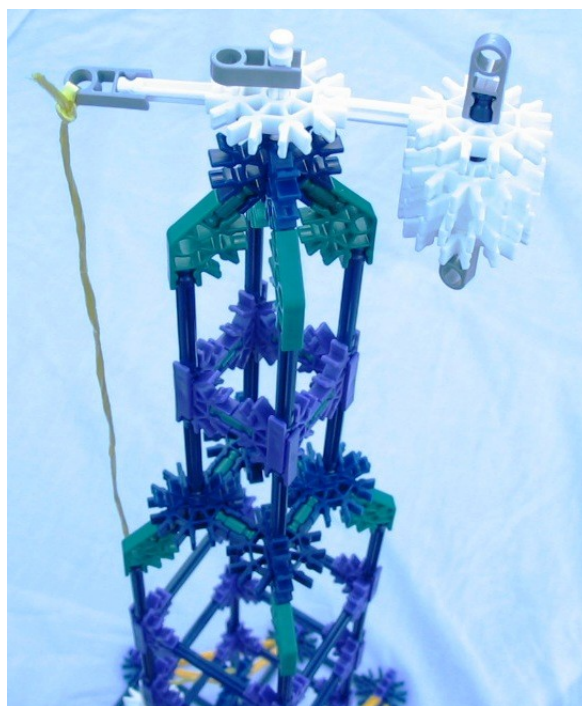
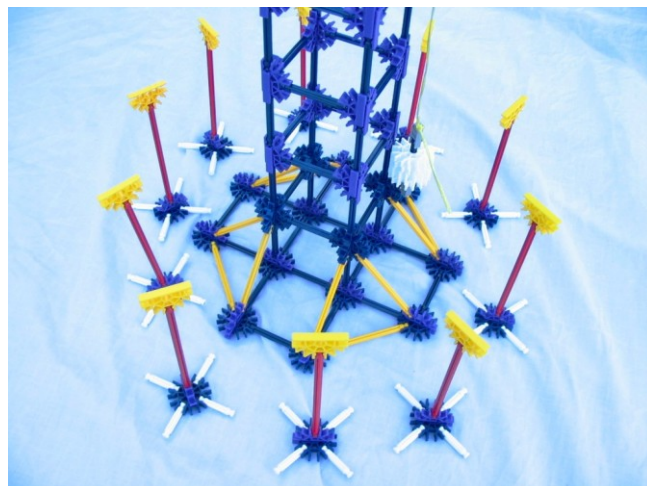
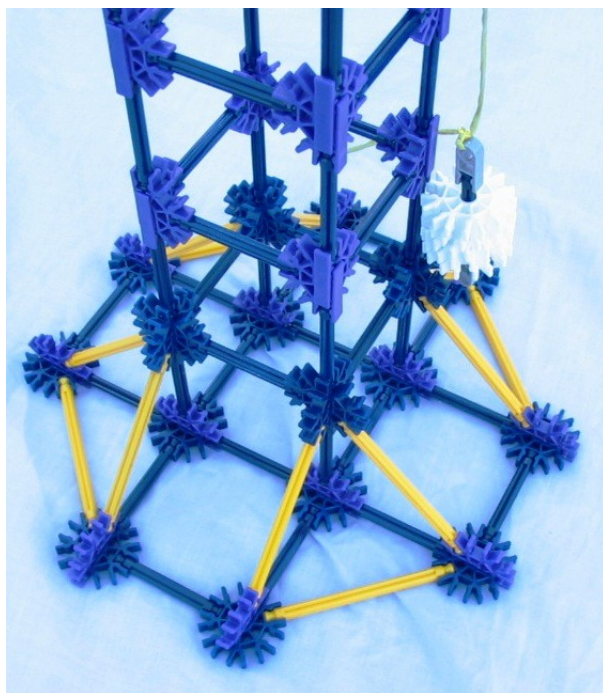
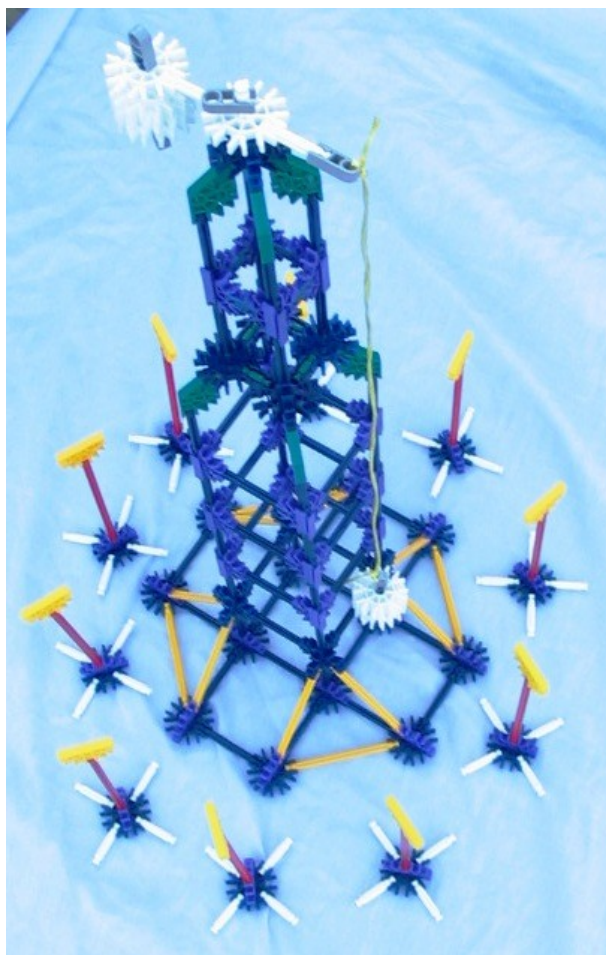
For players with less skill, you might number the dart board with numerals 1 to 8, and score upwards from zero to (say) 101.

You can also search for variations on the game of darts on the internet. There are many of them, all of which require number skills to a greater or lesser degree.

52. Ten-pin skittles

For 2-4 players

Build the tabletop skittles model and the ten “pins” shown below.



To play, stand the ten pins upright at equal spacing around the tower, and throw the weight so that it spins around the tower, and throw the weight so that it spins around the tower on the end of the string. You will need to adjust the length of the string so that a typical throw knocks over some, but not all, of the pins.

The simplest game is to score one point for each pin knocked over, with play then moving on to the next player.

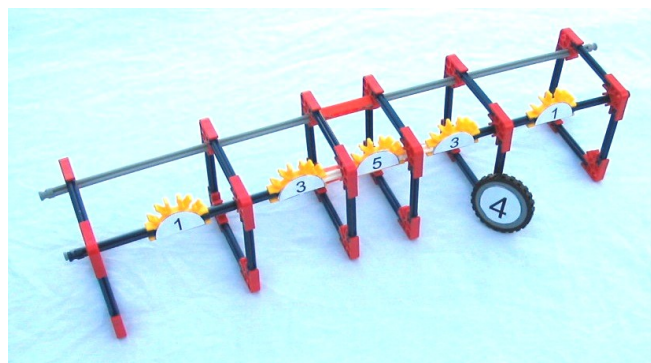
A better approach, if the number skill of the players are good enough, is to score the game as in ten-pin bowling, with each player having two throws before play moves on to the next player. In this way, a player can get a “strike” (all 10 pins on first throw), or a “spare” (all ten pins in two throws), and this causes the score on the next throw(s) by that player to be doubled.

53. Wheel roll

For 2-4 players

Extra equipment: 5 small K’NEX wheels, Numerals from Appendix B, sloping table.

Build the scoring box shown below, and attach the numerals 1 to 5 to five K’NEX wheels.



Put the scoring box at the end of a small table, and raise one end of the table by putting books under the legs at that end. Players score by letting go of a wheel at the high end of the table, so that it rolls down towards the scoring box. If the wheel enters one of the numbered compartments in the box, the player scores the multiple of the number on the wheel times the number of the compartment. For example, rolling a wheel with a 3 numeral into the compartment numbered 4 scores 12. If the wheel misses the box altogether, there is no score.

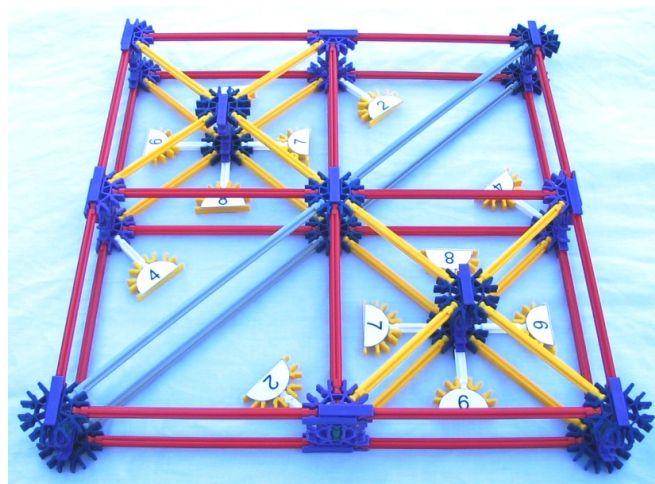
For players without the necessary multiplication skills, you may prefer to omit the numerals on the wheels, and just score using the compartment number. After the students have played the game a few times, you may like to suggest that they invent their own rules for this game.

54. Number box

For 2-4 players

Extra equipment: Numerals from Appendix B

Build the number box shown below.



Place the box in the middle of a small table, and give each player five white connectors. Players take turns to place their five connectors overhanging the edge of the table, and then flip each one into the box.

Scoring can simply be to add up the numbers on the compartments into which the five connectors are flipped, or you can invent a scoring method, such as one based on “Darts” or “Wheel roll” above.

55. Tower of Hanoi

For 1 player

Build the K’NEX model shown below.



The object of the game is to move all of the connectors to the rightmost rod, so that they end up in the same sequence. You may only move one connector at a time, and you must never allow a connector to rest on a smaller connector. Search “Tower of Hanoi” on the internet for further details.

4.2.3 Activities that are K’NEX challenges

All the Activities below are K’NEX “challenges”, for which no instructions are required. It is recommended that students complete some of the Activities earlier in this section before attempting any of these challenges.

56. Costed bridge

You are an architect who has been invited to enter a competition to design a new bridge to cross the Thames in London. At this stage, the competition organisers want to see a K’NEX model of your bridge, which must be strong enough to span a gap of 1m between two tables. The winning design will be the bridge that spans this gap at the lowest cost.

To cost your bridge design, use the following table:

Grey rod	£100
----------	------

Red rod	£70
Yellow rod	£45
Other rods	£30
White and blue connector	£60
Purple and yellow connector	£50
Other connectors	£35

In the event of two bridge designs being submitted with the same cost, the winning design will be the bridge that can support the most weight at its centre.

57. Costed desk tidy

A famous chain of office supplies stores wants to add a new “desk tidy” to their product range. The desk tidy will be built out of K’NEX, so that it can be sold ready-for-assembly, and it must be capable of holding five pencils, a ruler, 10 paper clips and an eraser. The desk tidy must be low cost, or customers will not buy it. Can you build an attractive K’NEX desk tidy for them, and cost it using the following table?

Grey rod	10p
Red rod	8p
Other rods	6p
White and blue connector	7p
Purple and yellow connector	5p
Other connectors	4p

Q1. How much do you think they ought to sell your desk tidy for?

58. Shopping trolley game

Q1. Can you design and build a shopping trolley with K’NEX, and then invent a game for young children in which they must throw a dice, and then fill up their shopping trolley with items priced from £1 to £6, according to the number thrown?

59. Ludo-like game

Q1. Can you make a board out of K’NEX which is similar to a Ludo or Monopoly board, and then invent a game to play on it?

4.3 Measure

All the activities in this subsection relate to measure. The questions shown against each Activity are only examples – you may wish to think up your own questions for each activity, that best suit the ability and experience of your students.

4.3.1 Activities from instructions

The activities below can be completed from the instructions provided.

60. Learning about area and perimeter

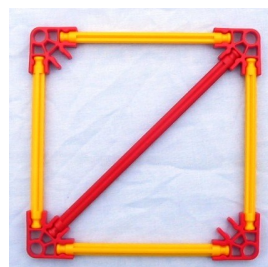
Build the square shown below:



Q1. Use a ruler to measure the length of the one of the sides of the square in mm. Now calculate the perimeter of the square (the length of all four sides together) and the area of the square (length x width).

Q2. Make a rectangle out of red and yellow rods, and calculate its perimeter and area.

Now put a red rod across the diagonal of the yellow square above.



This demonstrates that the area of a right angle isosceles triangle is half the area of the square in which it is contained.

Now build the equilateral triangle below.

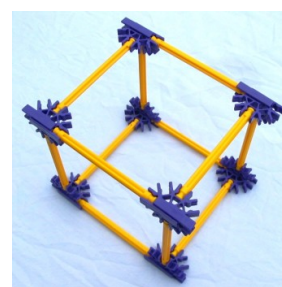


Q3. Use a ruler to measure the length of the one of the sides of the triangle in mm. Now calculate the perimeter of the triangle (the length of all three sides together).

Q4. Also measure the height of the triangle, and then calculate the area of the triangle (half the base x height).

61. Learning about volume

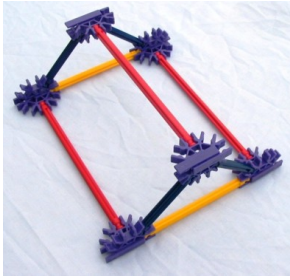
Build the K’NEX cube below.



Q1. Use a ruler to measure the length of the one of the sides of the cube in mm. Now calculate the volume of the cube (length x width x height).

Q2. Make a cuboid out of 8 red and 4 yellow rods, and calculate its volume.

Build the K'NEX prism below.

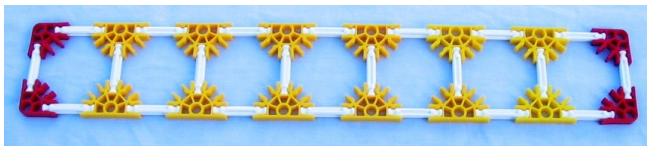


Q3. Calculate the volume of the prism, which is the area of the triangle at one end, times the length.

Q4. Build some other 3D shapes out of K'NEX, and calculate their volume.

62. Ruler

Make the K'NEX ruler below.



Q1. Use the ruler to measure the length of some everyday objects around the room.

63. Pair of compasses

Make the pair of K'NEX compasses below.



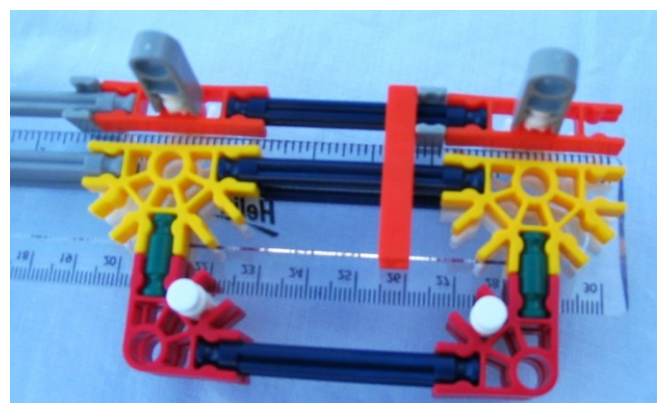
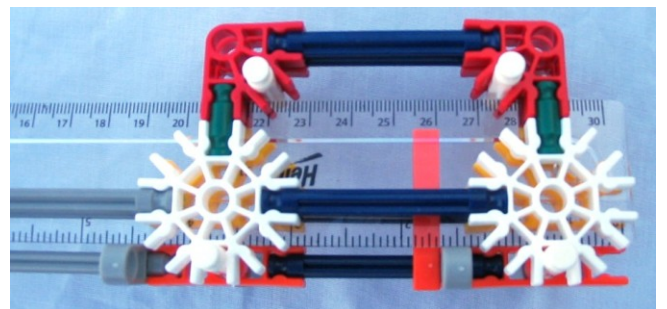
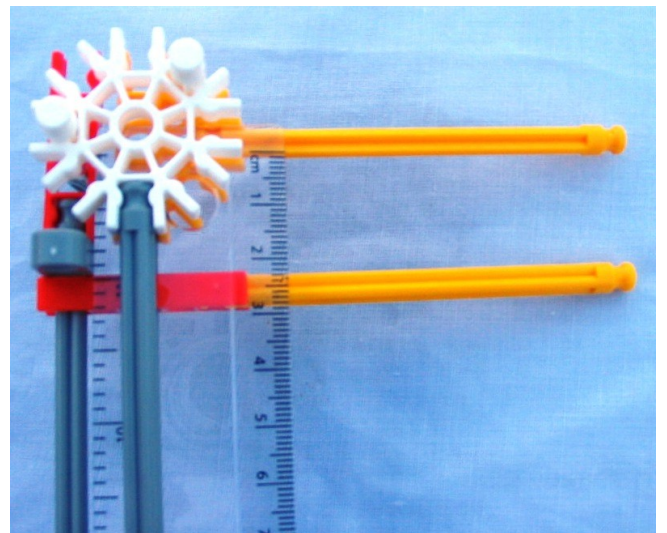
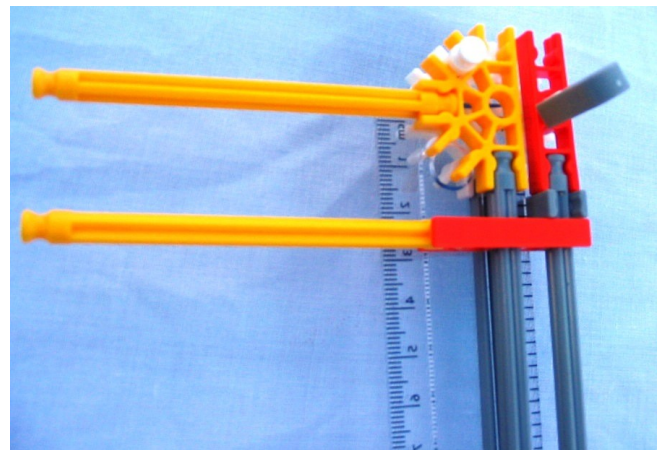
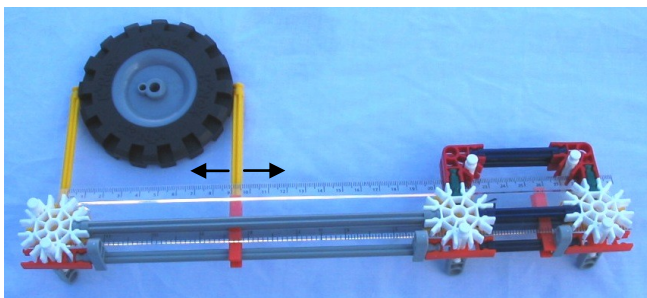
The pointer shown in the photo can be made by sharpening a blue K'NEX rod with a pencil sharpener until it has a blunt point.

Q1. Use the compasses to draw circles with five different diameters.

64. Calipers

Extra equipment: Ruler

Make the K'NEX callipers shown below.



Fix a ruler onto the callipers, so that the inside edge of the left-hand jaw is aligned exactly to zero on the ruler. The other jaw is designed to slide, so that it can be moved to touch the outer edge of the object being measured. You can then read off the object's length on the ruler.

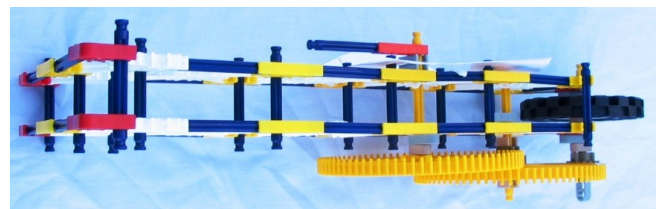
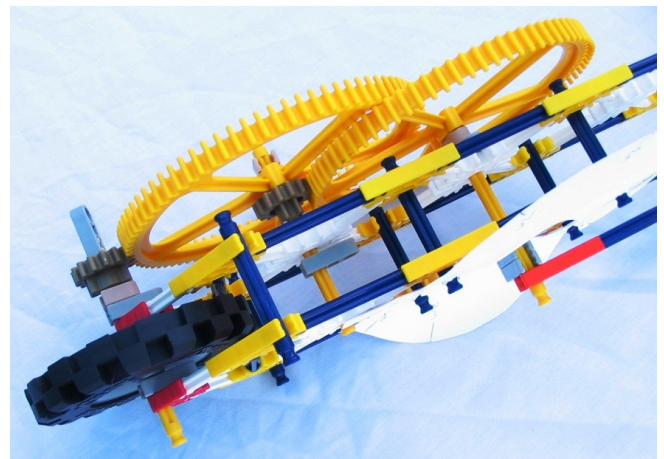
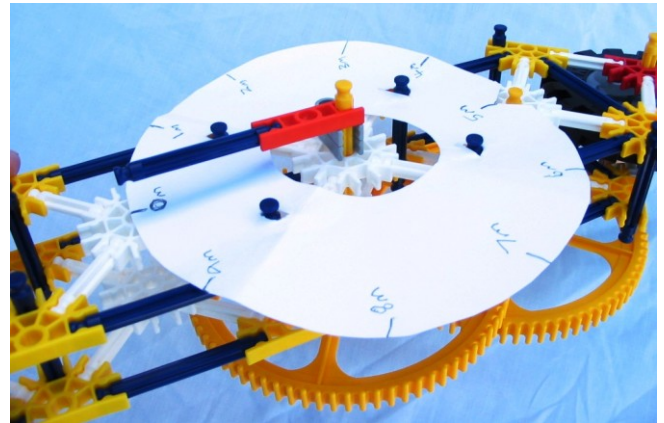
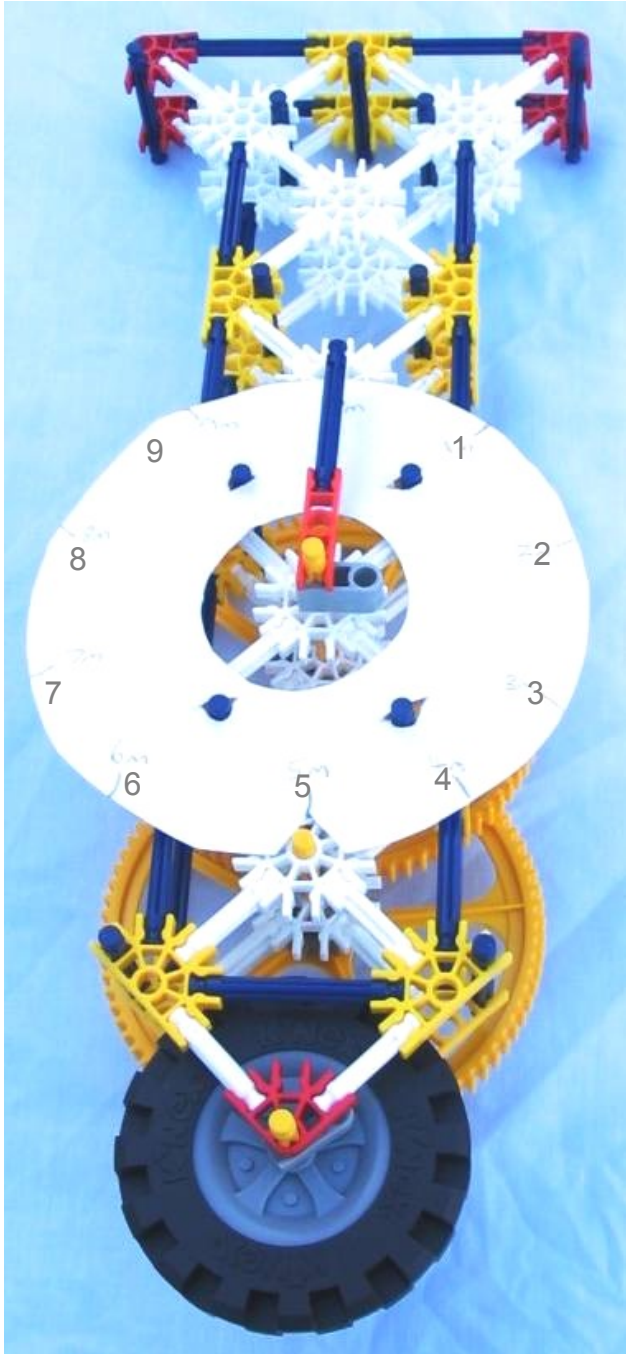
Q1. Can you use the callipers to measure the length of some small objects, and the diameter of a ball?

65. Measuring wheel

Extra equipment: Sheet of thin white card, 2 large gear wheels, 2 small gear wheels

Make the K'NEX measuring wheel opposite.

Affix a sheet of card beneath the pointer, and align the pointer so that it points vertically when the wheel is on the ground. Mark this position as 0m. Now run the measuring wheel along a 10m tape measure, and mark off the position of 1m, 2m, 3m etc.



Q1. Can you use your measuring wheel to measure the length and width of the room you are now in?

Q2. Can you use your measuring wheel to make a plan of the building you are in, and its grounds? (see also Activity 76)

66. Water tank

Extra equipment: supermarket carrier bag

Make the K'NEX water tank below.



Q1. Calculate the volume of the tank in mm^3 , and convert the volume into millilitres.

Q2. Fill the tank with water, to test whether your calculation is correct. Why might there be a small difference between the calculated value and the measured value?

67. Weighing scales

Extra equipment: Small weights

Make the K'NEX weighing scales below.



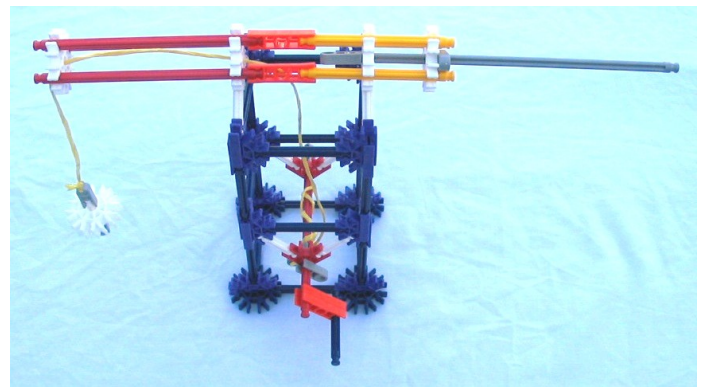
Q1. Use the scales to measure the weight of a number of small objects.

You may need to adapt the ends of the arms, so that they can support the weights and the objects you have chosen.

68. Crane

Extra equipment: string, selection of objects to lift

Make the K'NEX crane below.



Q1. Find the heaviest object that your crane can lift without it falling over.

Now modify your crane by adding white connectors to the grey "counterweight" arm.

Q2. Again find the heaviest object that your crane can lift without it falling over.

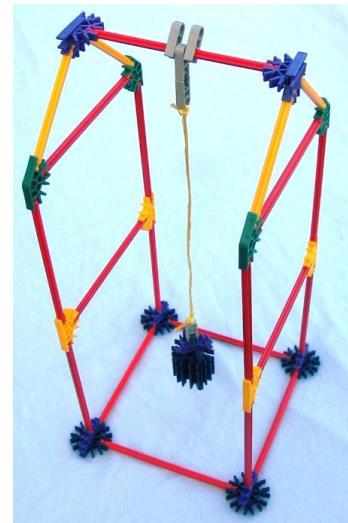
Q3. Why does increasing the distance between the counterweight and crane enable the crane to lift heavier weights?

Q4. Can you adapt your crane to lift even heavier weights?

69. Pendulum

Extra equipment: string

Make the K'NEX pendulum below.



Grandfather clocks use a pendulum to measure time.

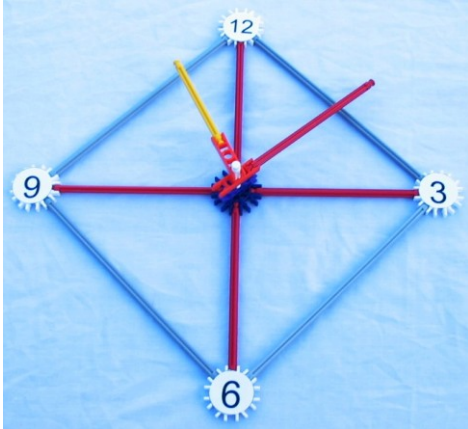
Q1. How many times will your pendulum swing backwards and forwards in one minute?

Q2. Does it make a difference how high the pendulum starts to swing from?

70. Clock face

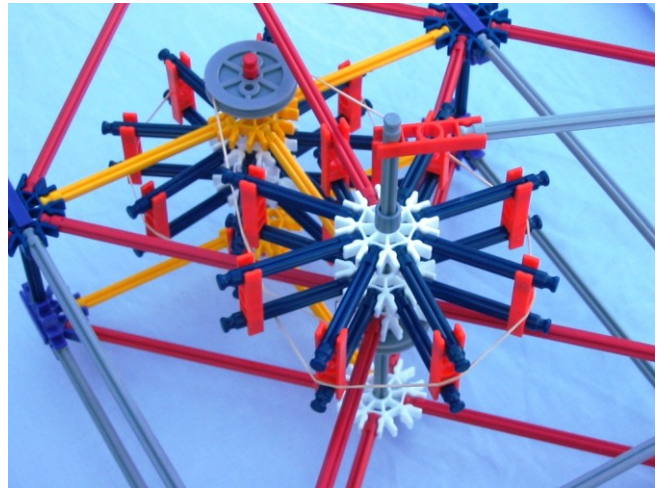
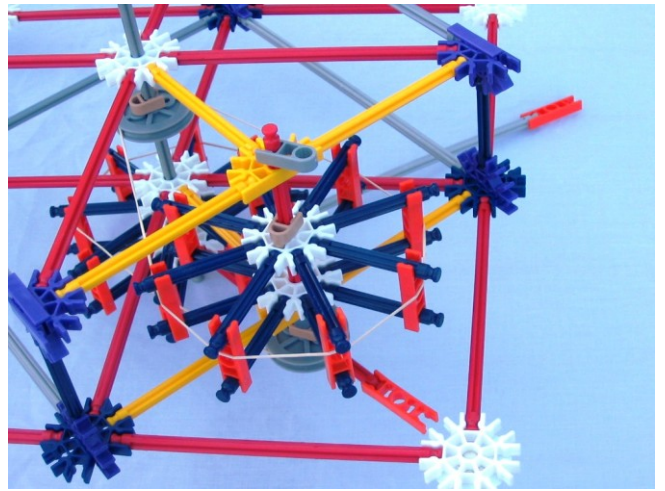
Extra equipment: Numerals from Appendix B

Make the K'NEX clock face below.



You may prefer to provide a clock face beneath the hour and minute hand which has the numerals 1 to 12 written on a circular sheet of white card, rather than just using the numerals 3, 6, 9 and 12 as shown above.

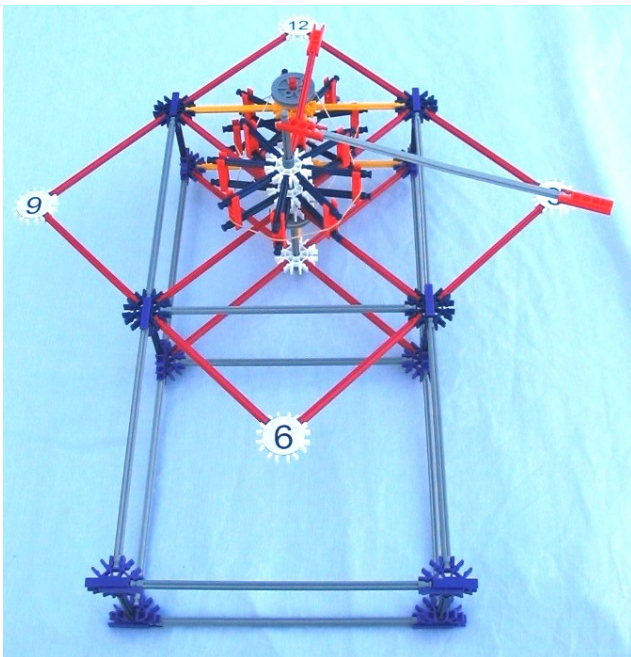
Q1. Can you set the clock to 6 o'clock, quarter past 5, and twenty to 10?



71. Analogue clock

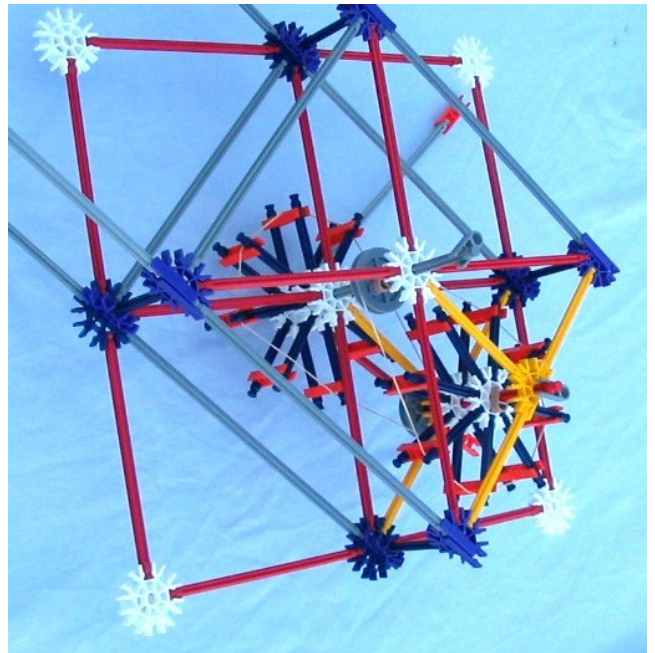
Extra equipment: Numerals from Appendix B, 2 rubber bands

Make the K'NEX clock below.



You will need to adjust the diameter of the two pulleys made from blue rods and orange connectors, so that the hour hand turns at the right speed in relation to the minute hand.

You may prefer to provide a clock face which has the numerals 1 to 12 written on a circular sheet of white card beneath the hour and minute hand, rather than just using the numerals 3, 6, 9 and 12 as shown above.



Q1. How many times does the big hand go around when the little hand goes around once?

Q2. Can you use the clock to find the time difference between quarter to 2 and twenty past 3?

72. Digital clock

Extra equipment: Numerals from Appendix B

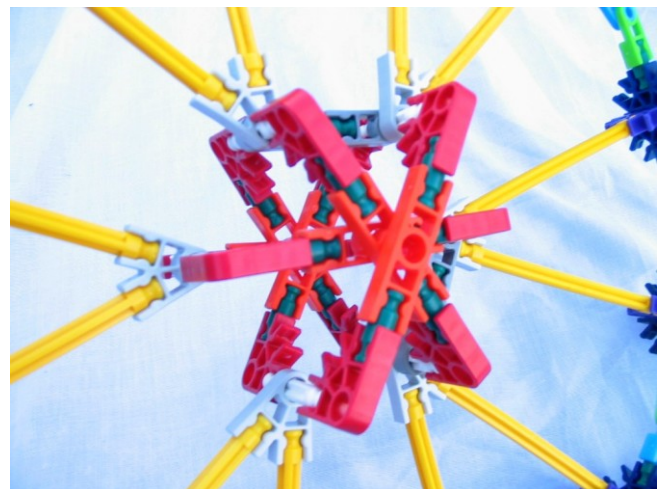
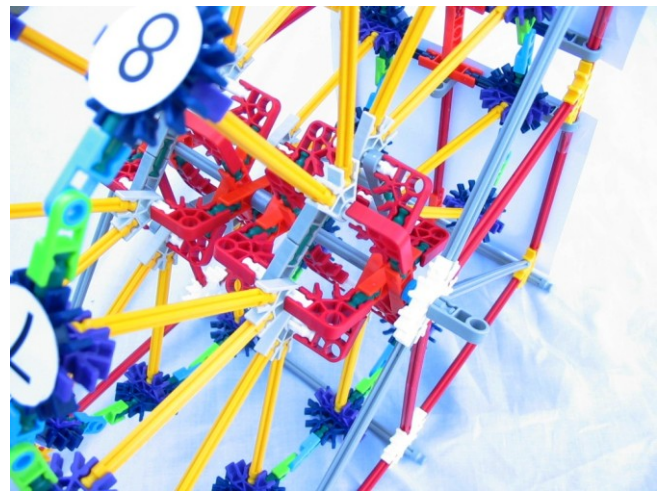
Make the K'NEX digital clock below.



Front



Rear

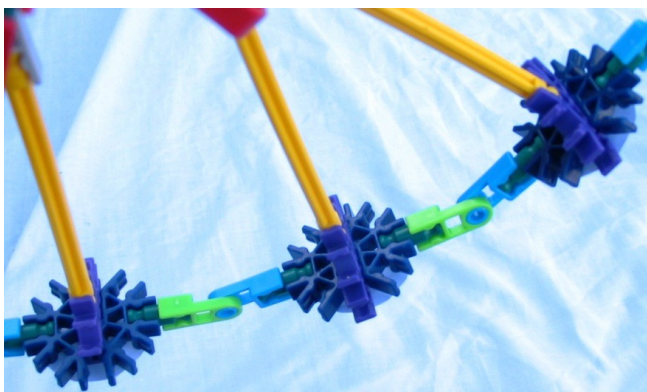


Note that the minute wheel only shows the time in 5 minute intervals.

Q1. Use the clock to show the time your lesson started and the time your lesson will finish.

Q2. Can you use the clock to find the time difference between 7:45 and 10:20?

Q3. How would the clock need to be changed to become a 24-hour digital clock?



73. Sundial

Extra equipment: Sheet of thin white card

Make the K'NEX sundial below.



Now place a sheet of thin white card over the base of the sundial, and put it outside in the sunshine. At each hour and half hour, mark off the position of the shadow onto the card.

As an alternative, you can use a torch to create the shadow in a darkened room, and simulate the sun moving.

74. Speed investigation - ramp

Extra equipment: ramp, stop watch

Make the K'NEX racing car shown below.



Use a board to build a ramp that is about 1.5m long, and set it at an angle of 30° to the floor, with a clear, bare floor in front of it for the cars to run on. Mark a finishing line across the floor approximately 3m in front of the bottom of the ramp. Measure the exact distance between the top of the ramp and the finishing line.

To race a car, place it at the top of the ramp, and then let it go. Use a stop watch to record the start time, and the finish time, when the back of the car crosses the finishing line.

Q1. Can you calculate the average speed of your car between the start line and finish line? Can you improve your car so that it will go faster?

Q2. Does the angle of the ramp make a difference to the average speed? Create a table, that shows the speed of the car for different angles between 10° and

60° . Use a spreadsheet to create a line graph or bar chart from this table.

Q3. How far does your car go before it stops altogether? Can you calculate the average speed between the starting point and stopping point?

Q4. During which part of the journey is your car going fastest? Could you measure its speed at this point?

75. Speed investigation - pendulum

Extra equipment: string, stop watch

Make the K'NEX pendulum from Activity 69. Using a stop watch, calculate how many times it takes for the pendulum to swing ten times, from a given starting point. Measure the distance of the pendulum's swing, and then calculate the average speed of the pendulum.

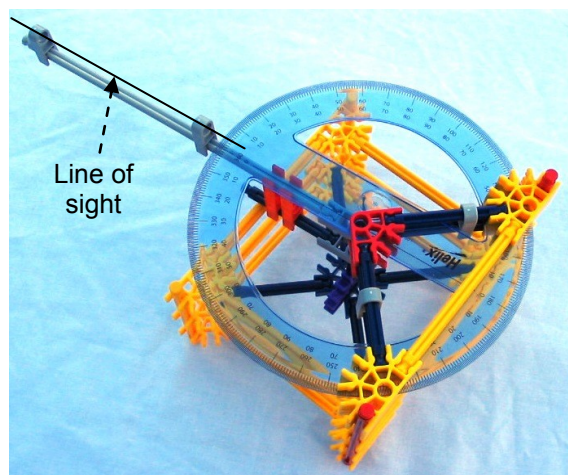
Repeat the investigation from different starting points, and produce a table and line graph of the results.

Q1. Does the time taken to swing ten times vary with the different starting points you have chosen?

76. Theodolite

Extra equipment: Sheet of thin white card, 360° protractor

Make the K'NEX theodolite below, and affix the 360° protractor as shown.



A theodolite is used to measure angles between buildings and other distant objects in the landscape when making maps. To do this, you must look down the line of sight at the first distant object, and record the angle shown on the protractor. Then rotate the line of sight so you can look down it to see the second distant object, and again record the angle. Finally, subtract one angle from the other to find the angle between them.

You can also use the measuring wheel from Activity 65 to measure distances for your map. The process of measuring angles and distances for a map is known as “surveying”. Search for “surveying” on the internet to find out how to create a map from angles and distances.

Q1. Can you use your theodolite together with the measuring wheel in Activity 65 to make a map of the grounds of the building you are in, or a local park or field?

77. Level or Sextant

Extra equipment: Sheet of thin white card, 360° protractor

You can also use the K’NEX theodolite from Activity 76 as a level or sextant, to measure the angle between two distant objects in the vertical plane.

The measuring wheel and theodolite allow you to make simple 2D maps, but they take no account of the height of different objects on the map. The Level can be used when surveying to determine the height of distant objects, by measuring the vertical angle of a line between the Level and the distant object. Search the internet to find how to create a 3D map from horizontal angles (theodolite), vertical angles (Level) and distances.

Q1. Can you use your Level to add contour lines to the map you made in Activity 76?

Q2. Sextants used to be used to help ships to find their position at sea. Use the internet to find out how your Level could be used as a sextant.

4.3.2 Activities that are games

The activities below are games that will help develop measuring skills.

78. Timed challenge

2 to 4 players

Measure how many times the Pendulum in Activity 69 will swing in 30 seconds. Place a box of K’NEX on the table in front of the players.

Each player takes it in turn to try and build as tall a K’NEX tower as they can in successive turns of 30 seconds. Everyone else counts out loud the number of swings of the pendulum, until the finish time is reached.

As an alternative, a clock can be used to count the seconds out loud.

4.3.3 Activities that are K’NEX challenges

All the Activities below are K’NEX “challenges”, for which no instructions are required. It is recommended that students complete some of the Activities earlier in this section before attempting any of these challenges.

79. Rubber band scales

Extra equipment: 4 rubber bands, weights from 100g to 1Kg, white card

Make a K’NEX cage to hold one or more weights, and hang it from a K’NEX frame. Affix a strip of white card vertically alongside the cage. Now use the weights in different combinations to “calibrate” the scales, by marking off the position of the cage when it is supporting 100g, 200g, 300g, etc.

Q1. Can you use your scales to weight small objects?

80. Map of New York City

Find a street map of New York City on the internet, and identify the position of well-known buildings such as the Empire State Building. Use K’NEX rods and connectors to make a street plan of an area of New York, and add in small models of the well known buildings. Mark the direction North on the plan.

Q1. Can you write down directions from the Empire State Building to another well-known landmark:

- By using “turn first right”, turn third left”, etc*
- By using compass directions and distance (go North West for 20m, turn South for 10m, etc).*
- By using the Logo language (forward 20, right 90, etc).*

81. Moon base

Use K’NEX to make six buildings you would need on a moon base, and lay these out with streets. Then build a moon buggy to travel along the street.

Q1. How far would the moon buggy have to travel to visit every building?

Q2. Can you give the moon buggy driver directions to visit every building?

4.4 Handling data

All the activities in this subsection relate to handling data. The questions shown against each Activity are only examples – you may wish to think up your own questions for each activity, that best suit the ability and experience of your students.

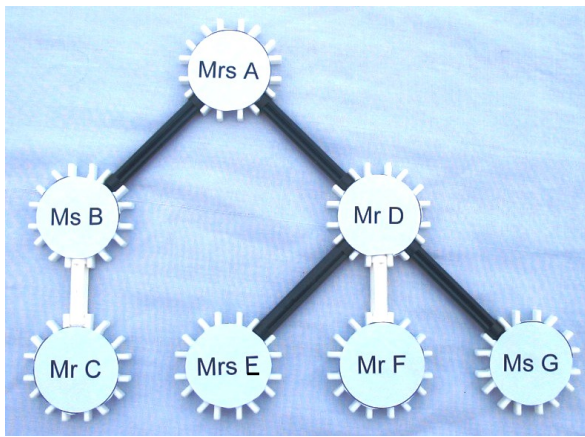
4.4.1 Activities from instructions

The activities below can be completed from the instructions provided.

82. Organisation chart

Extra equipment: Numerals from Appendix B (write on back)

K’NEX is good for making all sorts of diagrams in which interconnections are shown. Try the one below, which is the organisation chart for a company.



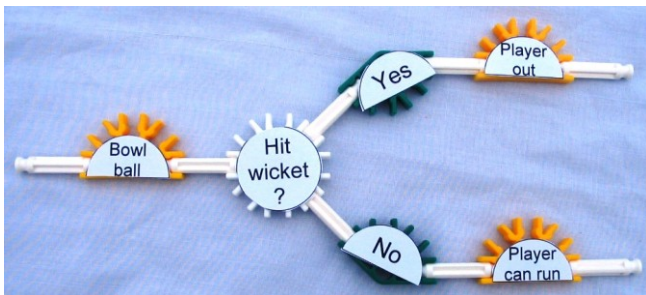
Q1. Who is the boss of Mr D?

Q2. Who works for Mr D?

83. Flowchart

Extra equipment: White card

K'NEX is also good for flowcharts. Build the one shown below.



Q1. Can you make a flowchart for a subject of your choice, using yellow, white and green connectors as above?

84. Data table

Extra equipment: White card

Data tables are normally drawn on paper, or entered directly onto a computer. However, building the frame of a data table out of K'NEX provides a hands-on alternative, that is particularly effective for displaying the data to others.

Build the data table below.

Blond	11
Black	12
Brown	16

Q1. Find out the number of students in your group that have blond, brown or black (or other colour) hair, and enter the numbers into a K'NEX data table.

Q2. Throw a dice 20 times, and make a K'NEX data table to record the number of times that the dice falls on 1,2,3,4,5 or 6.

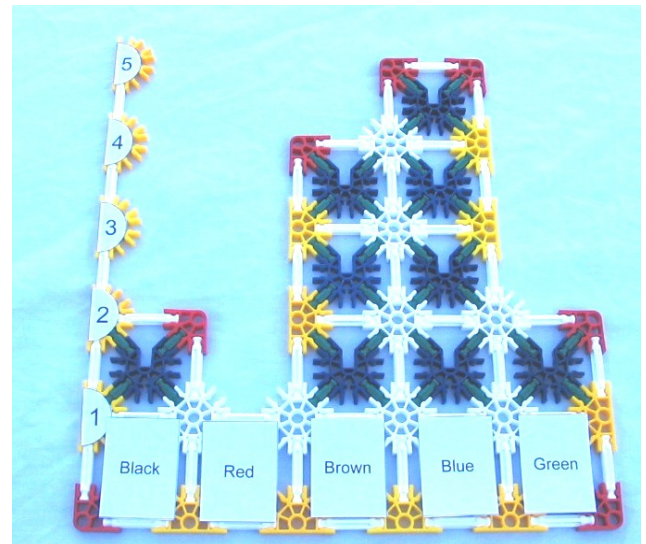
Q3. Make a K'NEX data table that contains a railway timetable or bus timetable for a local train or bus service.

85. Bar chart

Extra equipment: Numerals from Appendix B, White card

The process of converting computer-based spreadsheets into bar charts is very simple – so simple that students may not fully understand the steps that have been carried out. Making bar charts out of K'NEX gives students a deeper understanding of their production, gained by hands-on experience.

Build the bar chart below.



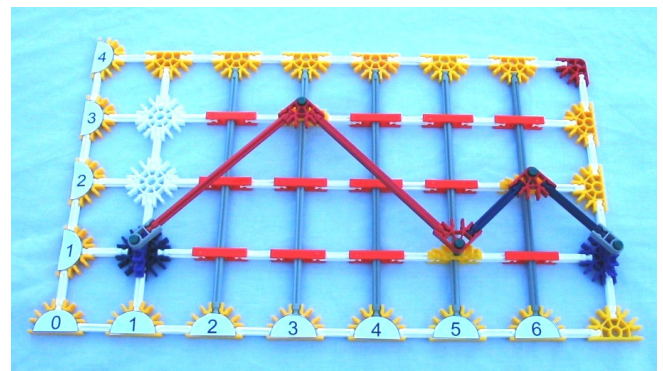
Q1. Can you make bar charts to show the results in the data tables you created in Activity 84?

86. Line graph

Extra equipment: Numerals from Appendix B

Attractive line graphs can also be built with K'NEX.

Build the line graph below.



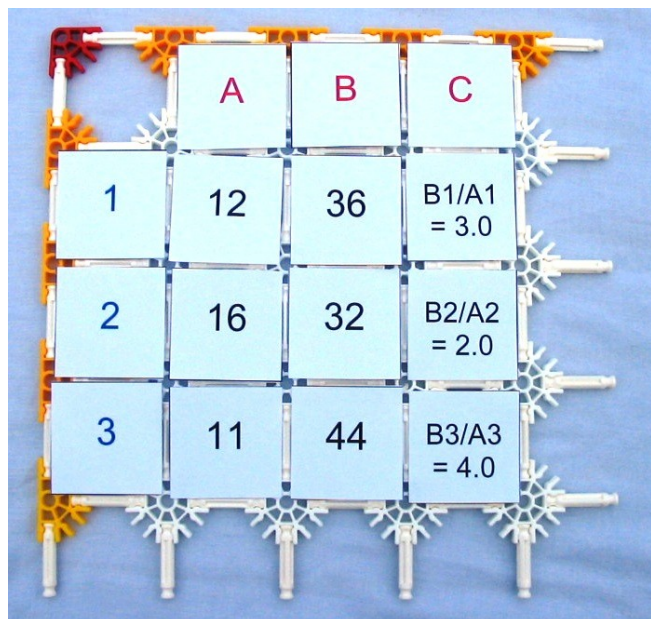
Q1. Can you make line graphs to show the results in the data tables you created in Activity 84?

87. Spreadsheet

Extra equipment: Numerals from Appendix B

Building a K'NEX spreadsheet can help students to better understand concepts such as rows, columns, cells and formulae.

Build the K'NEX spreadsheet below.



Q1. Can you enter the results from the first question in Activity 84 into a K'NEX spreadsheet?

Q2. Can you add an extra cell to calculate the total number of students, and an extra column that contains a calculation of the percentage of students with different colour hair?

88. Pick-a-connector

K'NEX rods and connectors can be used in many different ways to demonstrate probability. One of the simplest is to put a selection of different connectors into a bag, and ask students to select them one at a time.

Q1. Can you predict the probability of choosing a red connector?

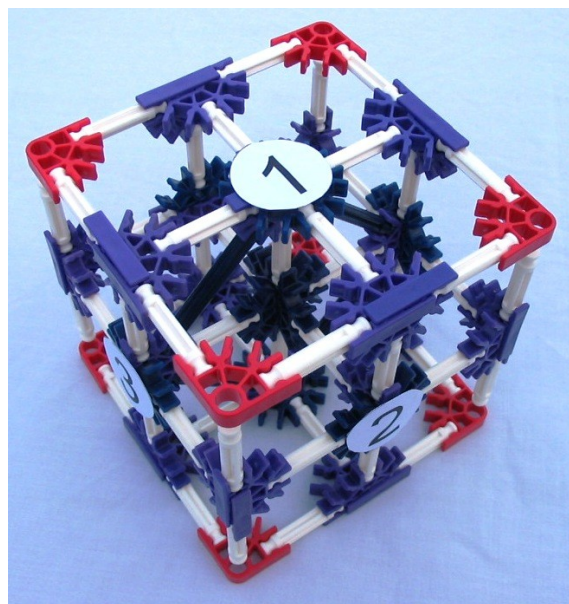
Q2. Can you predict the probability of choosing a red connector followed by a yellow connector?

89. Dice

Extra equipment: Numerals from Appendix B

Note that we use the word “dice” in this Guide to refer to a single dice, rather than the less common (and therefore possibly confusing) word “die” as the singular of the plural word “dice”.

Make the K'NEX dice below.



Q1. Predict how often the dice will show a 3 if you throw the dice 60 times. Now actually throw the dice 60 times. If your prediction is wrong, can you explain why?

Q2. If you were to make a second dice, how many different ways could you throw a total of 7? What is the probability of you getting a 7?

Q3. Can you use the dice to play one of the games in Section 4.2.2?

90. Four-sided spinner

Extra equipment: Numerals from Appendix B

Make the four sided K'NEX spinner below.



The spinner is used by spinning it, and then waiting until it stops on one edge.

Q1. Predict how often the spinner will show a 2 if you spin it 20 times. Now actually spin it 20 times. If your prediction is wrong, can you explain why?

Q2. Make a second four-sided spinner. How many different ways can you achieve a total of 5 with two spinners? What is the probability of you getting 5 if you spin both spinners at once?

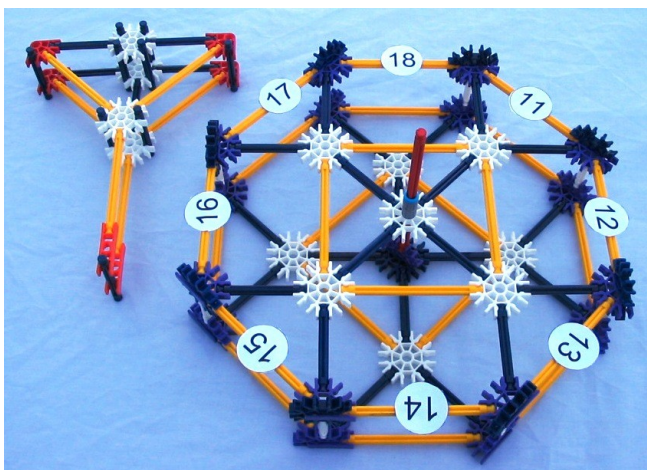
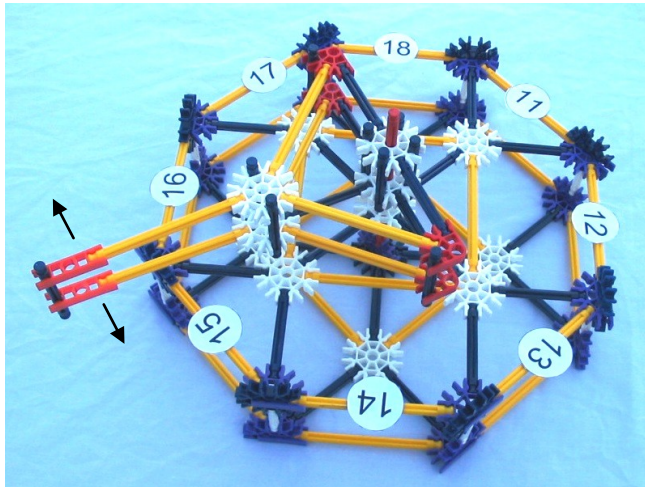
Q3. Can you use your two spinners to play one of the games in Section 4.2.2?

91. Number pointer

Extra equipment: Numerals from Appendix B

An alternative to a spinner is a pointer, which spins around in a static frame, and points to a number, colour or word when it stops.

Make the K'NEX pointer below.



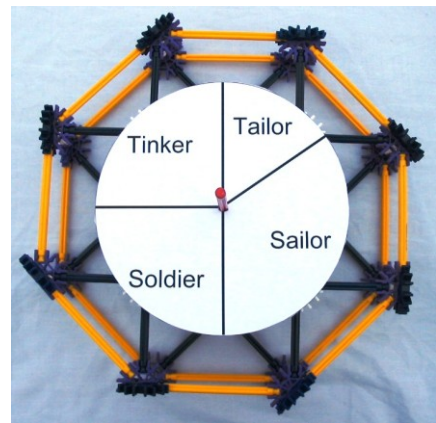
You should operate the pointer on a completely flat surface, and check that it not biased towards stopping in any one particular place before use.

Q1. Predict how often the pointer will stop on 15 if you spin it 80 times. Now actually spin it 80 times. If your prediction is wrong, can you explain why?

92. Horse-racing pointer

Extra equipment: White card

Modify the spinner from Activity 91 to make a horse-racing pointer, as shown below



You can set the size and number of the sectors of the circle to whatever value you like. When the pointer spins, the narrower the sector, the lower the probability of that horse winning when the pointer is spun.

Q1. Can you work out the probability of the pointer stopping on each of the horse's names.

93. Probability line

Extra equipment: Numerals from Appendix B

Make the probability line below, and use it to help students get a "feel" for probabilities between 0% and 100%.



Q1. How probable is it that the Labour Party will win the next General Election?

Q2. How probable is it that it will snow on Christmas Day?

94. Learning about mean, median, mode and range

Q1. Spin the number pointer from Activity 91 100 times, and write down the results in a table.

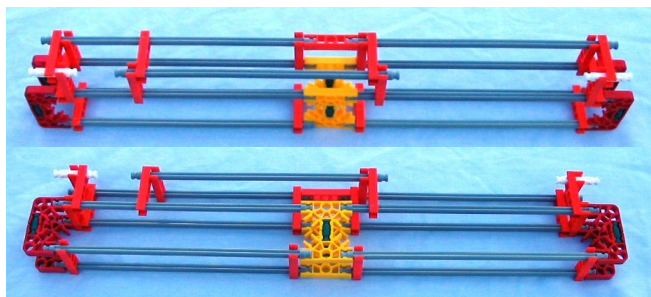
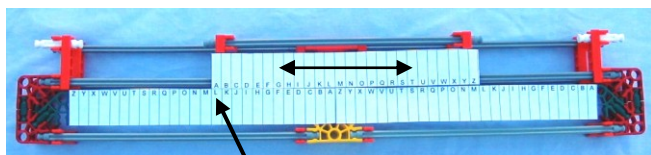
Q2. Use the data table to create a K'NEX bar chart.

Q3. Calculate the mode, median, mean and range of your results.

95. Coding machine

Extra equipment: White card

The Enigma machine was used in the second world war as a coding machine to keep messages secret. You can make a simple coding machine out of K'NEX, as shown below.



The top section slides backwards and forwards, to allow you to change the code as often as you want.

Q1. Can you use your coding machine to send secret messages to a friend?

4.4.2 Activities that are games

The activities below are games that will help develop data handling skills.

96. Predictions

2 to 4 players

Extra equipment: Four-sided spinner from Activity 90

Build the K'NEX stand below, with a row of eight upright rods for each player (only 3 rows shown).



The object of the game is for a player to put a yellow connector on all eight upright rods in his/her row. The players take turns to spin the spinner, and before spinning it, predict the number (1 to 4) that the number will stop on. If they are right, they add a yellow connector onto one of their eight upright rods.

The game can be made more sophisticated by using a spinner or pointer in which there is not an equal chance of the same number coming up. Eg a pointer with numbers placed in different sized sectors, similar to the horse names in different sized sectors in Activity 92.

97. Horse-racing game

2 to 4 players

Note that this is a betting game, but one that nevertheless will help students to understand probability.

Use the horse-racing spinner from Activity 92. One player acts as "Bookie", and sets odds for each horse name (eg 3:1 Tinker, 2:1 Tailor).

Before each spin, the other players place bets on a horse of their choice, using counters for money. The Bookie then spins the pointer. Winning players receive a payout calculated from the odds on the winning horse. All other players lose their bets.

You may wish to allow the Bookie to set odds that give him or her a statistical probability of winning more than he/she pays out, as in real life.

4.4.3 Activities that are K'NEX challenges

All the Activities below are K'NEX "challenges", for which no instructions are required. It is recommended that students complete some of the Activities earlier in this section before attempting any of these challenges.

98. Premiership table

Q1. Can you make a K'NEX data table which contains the names of all the football teams in the Premiership, and then keep it up to date after every match is played? Students may like to show for each team: wins, draws, losses, points, goals for and goals against.

99. School dinners

Q1. Can you make a K'NEX bar chart showing what students chose to eat for lunch?

100. Dice with more than six sides

Q1. A dice is simply a 3D object with six equal-sized faces, that falls on one face when thrown. Can you make a 3D object with more than six equal-sized faces, and invent a game to play with it?

101. Spinner with more than four sides

Q1. Can you make an eight-sided spinner from K'NEX, and invent a game to play with it?

Appendix A. Answers to questions

This Appendix contains answers only to those questions in Section 4 which have a definitive answer.

A.1 Shape and Space

Activity 4

Q1. The triangle in this activity is an equilateral triangle. The triangles in Activity 3 are all isosceles triangles.

Q2. The angles in the equilateral triangle are all 60° .

Activity 5

Q1. One way to achieve this is to make one square with sides of blue rods, and the other with sides of green rods.

Q2. No

Q3. Yes

Q4. Yes

Activity 7

Q1. 45° and 135° .

Activity 8

Q1. 45° and 135° .

Activity 9

Q1. 135° .

Activity 10

Q1. All the right-angled triangles in Activity 3 other than the smallest can be filled in with two triangles. All the squares in Activity 5 can be filled in with two or more triangles.

Q2. The rectangle in Activity 6 can be filled in with a combination of triangles and squares, as can the octagon in Activity 9.

Activity 11

Q1. 45° , 90° and 135° .

Activity 12

Q1. Yes

Q2. Examples - "7" can be rotated to become the letter "L", and "9" can be rotated to become "6".

Activity 13

Q1 The shape is symmetrical about a vertical line through its centre and also a horizontal line through its centre.

Q2. Yes

Q3. Activity 3 – each has 1 line of symmetry. Activity 4 – 3 lines. Activity 5 – 4 lines. Activity 6 and 7 – 2 lines. Activity 8 – 1 line. Activity 9 – 8 lines. Activity 10 – 4 lines. Activity 11 – 8 lines.

Activity 14

Q1. A rectangle.

Q2. (3,1) and (1,3).

Activity 15

Q1. "M" - Forward 190, Right 135, Forward 85, Left 90, Forward 85, Right 135, Forward 190. "N" – Forward 130 (a red rod), Right 135, Forward 190, Left 135, Forward 130.

Activity 16

Q1. Answer by measurement.

Q2. The copied square will be the same size.

Q3. The copied square will be smaller.

Activity 18

Q1. 6.

Q2. A square.

Activity 20

Q1. A square.

Q2. Triangles.

Activity 21

Q1. A triangle.

Q2. Rectangles.

Activity 23

Q1. Cube – 6 lines of symmetry. Cuboid – 3 lines.

Pyramid – 1 line. Prism – no lines.

A.2 Number

Activity 31

Q1. 8.

Q2. 1.

Q3. 4.

Activity 33

Q1. 8, 12 and 16.

Activity 34

Q1. 4, 7, 6, 2.

Q2. 0, -2, -2.

Activity 36

Q1. 3.

Q2. Answer by experiment.

Activity 37

Q1. Answer by experiment.

Q2. Answer by experiment.

Activity 38

Q1. 49 rods at 5p and 23 connectors at 10p = £4.75. This answer assumes that a double-purple connector counts as one connector.

Activity 39

Q1. The fan turns about $2\frac{1}{2}$ times for every turn of the handle.

Q2. The number of teeth on the two gear wheels determines the gear ratio. The small wheel has 14 teeth, and the larger wheel has 34 teeth, giving a gear ratio of 34/14.

Activity 40

Q1. $\frac{1}{2}$

Q2. $\frac{1}{4}$

Activity 41

Q1. 16.

Q2. 36.

Q3. 7.

Q4. 27.

Q5. 4.

Activity 43

Q1. 7

Q2. 7.

Activity 44

Q1. 8 yellow rods and 4 double-purple connectors.

Q2. 24 blue rods and 16 white connectors.

Activity 45

Q1. Four-level – $36Y + 20P$, Five-level – $44Y + 24P$.

Q2. $4Y + 4P + L(8Y + 4P)$.

A.3 Measure

Activity 60

Q1. Perimeter is $4 \times 115 = 460\text{mm}$. Area is $115 \times 115 = 13,225\text{mm}^2$.

Q2. Perimeter is $2 \times 115 + 2 \times 160 = 550\text{mm}$. Area is $115 \times 160 = 18,400\text{mm}^2$.

Q3. Perimeter is $3 \times 115 = 345\text{mm}$.

Q4. Area is $100 \times 115/2 = 5,750\text{mm}^2$.

Activity 61

Q1. Volume is $115 \times 115 \times 115 = 1,520,875\text{mm}^3$.

Q2. Volume is $115 \times 160 \times 160 = 2,944,000\text{mm}^3$.

Q3. Area of triangle = $115 \times 85 = 9,775\text{mm}^2$. Volume is $9775 \times 160 = 1,564,000\text{mm}^3$.

Activity 66

Q1. Volume of cube is $115 \times 115 \times 115 = 1,520,875\text{mm}^3$, which is 1521ml.

Q2. The differences will arise because a) the rods and connectors take up some of the volume and b) the bag bulges outwards when filled with water.

Activity 68

Q3. Balance is achieved when [Weight] x [Distance of weight from centre of tower] is the same on both sides. A heavier weight on one side can therefore be balanced by increasing the distance of the weight on the other side from the centre.

Activity 69

Q1. In a perfect pendulum, the answer to this question is no, as the lower the starting point, the slower the pendulum will travel. However, friction in the K'NEX pendulum may result in there being some variation.

Activity 71

Q1 12.

Q2. 95 minutes.

Activity 72

Q2. 155 minutes.

Q3. One way to achieve this would be to build an "hour wheel" with 24 different hour numerals, from 00 to 23.

Activity 75

Q1. In a perfect pendulum, the answer to this question is no, as the lower the starting point, the slower the pendulum will travel. However, friction in the K'NEX pendulum may result in there being some variation.

A.4 Handling data

Activity 82

Q1. Mrs A.

Q2. Mrs E, Mr F and Ms G.

Activity 89

Q1. The probability is that the dice will show a three ten times in 60 throws. Throwing a perfect dice will only result in a three on average 1 out of every six throws, so there is no guarantee that 10 throws out of 60 will be a three. Also, the K'NEX dice is not perfect, and may be biased towards certain sides because of irregularities, or because of the throwing style.

Q2. Seven can be achieved as $1 + 6$, $6 + 1$, $2 + 5$, $5 + 2$, $3 + 4$ or $4 + 3$. Probability of getting a seven is therefore 6 in 36 possibilities ie $1/6^{\text{th}}$.

Activity 90

Q1. The probability is that the spinner will show a two five times in 20 spins. Spinning a perfect spinner will only result in a two on average 1 out of every four throws, so there is no guarantee that 5 spins out of 20 will be a two. Also, the K'NEX spinner is not perfect, and may be biased towards certain sides because of irregularities, or because of the spinning style.

Q2. Five can be achieved by $1 + 4$, $4 + 1$, $2 + 3$ or $3 + 2$. Probability of getting a five is therefore 4 out of 16 possibilities ie $1/4$.

Activity 91

Q1. The probability is that the spinner will show a 15 ten times in 80 spins. Spinning a perfect spinner will only result in a 15 on average 1 out of every eight throws, so there is no guarantee that 10 spins out of 80 will be a 15. Also, the K'NEX spinner is not perfect, and may be biased towards certain sides because of irregularities, or because of the spinning style.

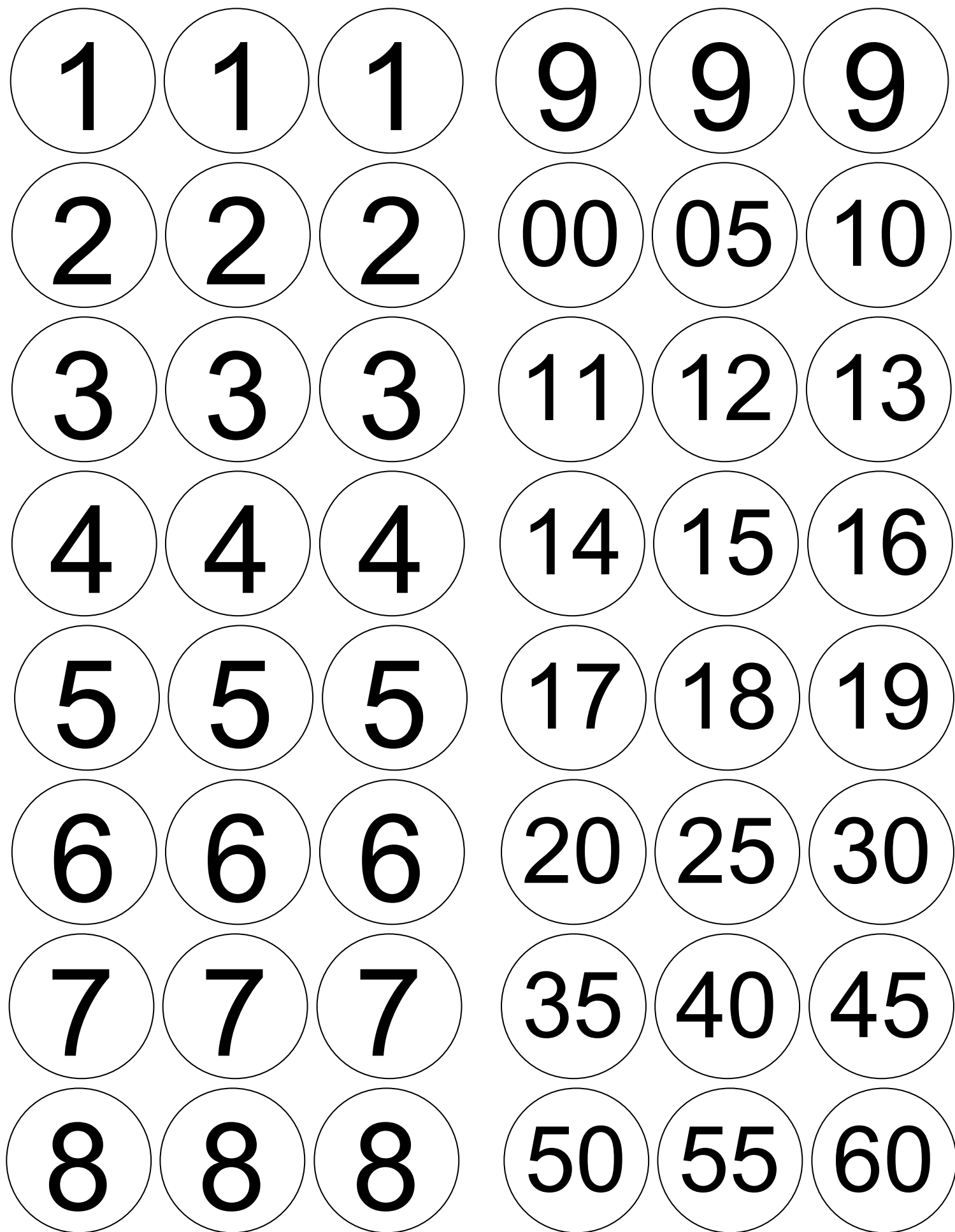
Activity 92

Q1. Tinker 25%, Tailor 12.5% Sailor 37.5%, Soldier 25%.

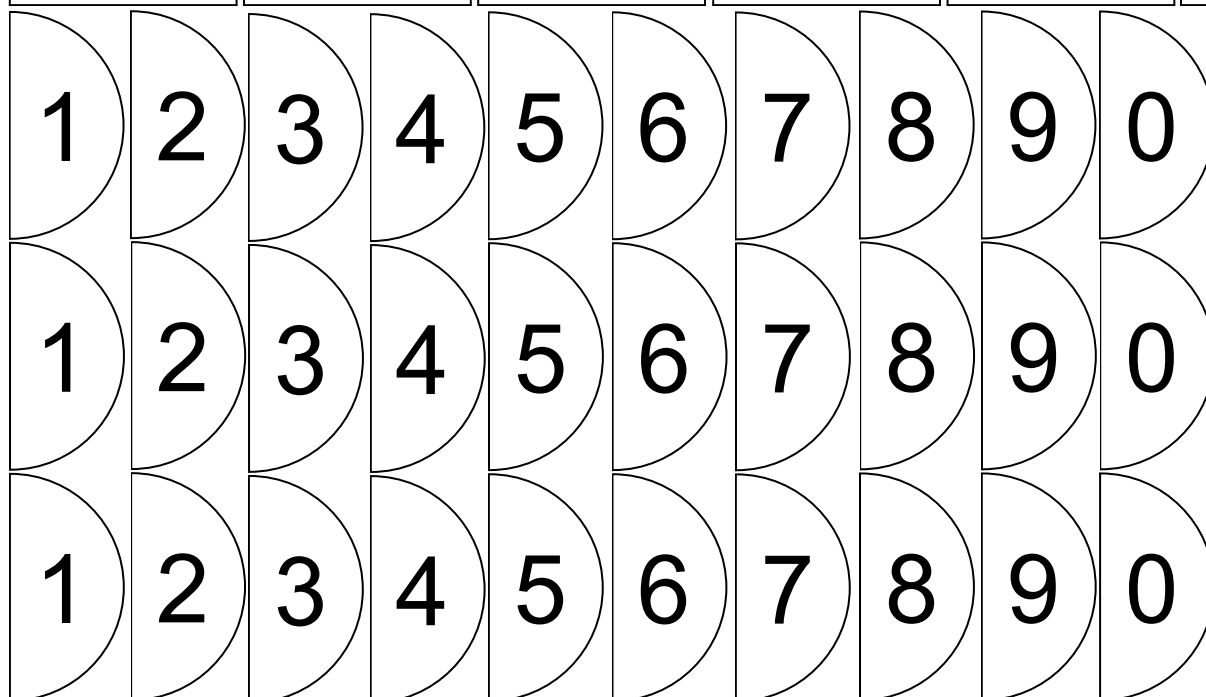
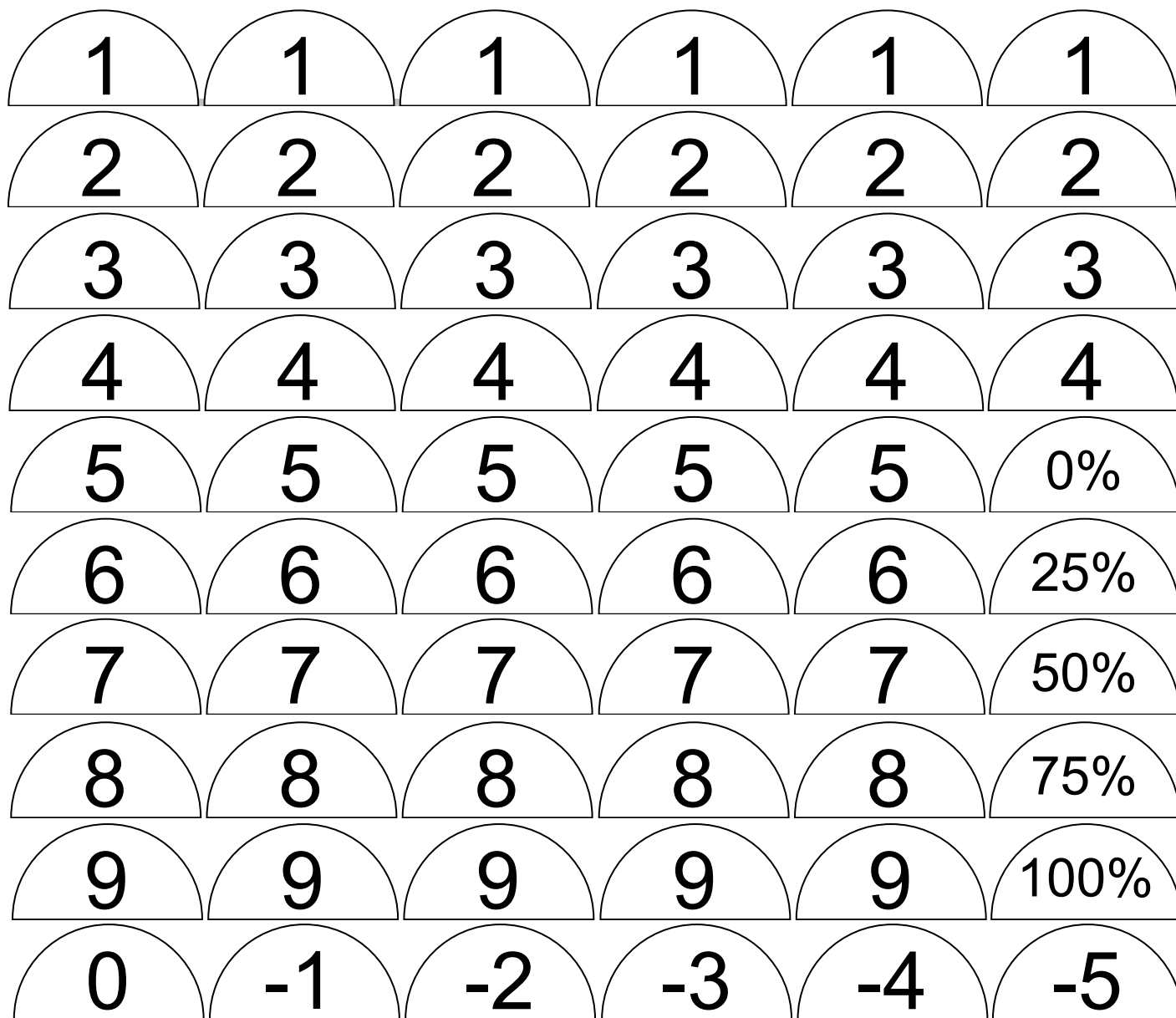
Appendix B. Number sheets

The number sheets in the following three pages are designed to be photocopied, cut out and attached to K'NEX white or yellow connectors.

If you want any blank labels, we suggest you print out one of the number sheets, cut out labels of the desired size, and then write on the back in thick felt pen.



1p	1p	1p	0	0	0
2p	2p	2p	-1	-1	-1
5p	5p	5p	-2	-2	-2
10p	10p	10p	-3	-3	-4
20p	20p	20p	-4	-5	-5
50p	50p	50p	-6	-6	-7
£1	£1	£1	-7	-8	-8
£2	£2	£2	-9	-9	-10



Appendix C – K’NEX Order Form

K’NEX Elementary Maths set



A starter set that provides a good introduction to the use of K’NEX to learn about shape and space.

The set includes:

- 143 pieces to complete 11 different activities from instructions
- Strong, plastic compartmentalized storage cases.
- Comprehensive full-colour instruction manual

Suggested age range: **5+**

Number that one set can support: **2 students**

K’NEX Intermediate Maths set



A medium-sized maths set that provides a good range of K’NEX maths activities, covering mainly shape and space. The set includes:

- 920 pieces to complete 28 different activities from instructions
- 2 strong, plastic compartmentalized storage cases.
- Comprehensive full-colour instruction manual

Suggested age range: **5+**

Number that one set can support: **6 students working in groups of 3**



K’NEX Discovery building set



A general purpose set that provides a good introduction to K’NEX and its capabilities.

The set includes:

- 259 pieces to build 20 different models from building instructions
- Strong, plastic compartmentalized storage cases.
- Comprehensive full-colour instruction manual

Suggested age range: **5+**

Number that one set can support: **2 students**

K’NEX Simple machines deluxe set

An enormous K’NEX set that is ideal as a general-purpose K’NEX resource for schools, clubs, childcare schemes and family learning.

The set includes:

- 3,400 pieces of K’NEX.
- a mains-powered 12v motor
- 5 teacher’s guides (Levers, Pulleys, Gears, Wheel & Axles, Inclined Planes)
- 57 lesson plans for key stages 1 & 2
- instructions to build a science fair model, the 4’ tall Big Ball Factory



Suggested age range: **5 to 95**

Number that one set can support:

Supports 20-30 students working in teams of 2-3.



K'NEX Order form

To use this order form, please print it out, and fill in every field marked with an asterisk. Then fax to **(0208) 196 2248**, or mail to *K'NEX User Group, 87A Newton Road, Mumbles, Swansea SA3 4BN*. If you have any queries on completing this form, please email us via info@knexusergroup.org.uk

*Date ordered		*Your Purch. order ref.	
*Organisation			
*Address			
		*Postcode	
*Telephone		*Email	
*Name		*Position	
*Signature	(Order not valid unless signed)		

Part no.	Description	Price	*Quantity	*Value
78720	K'NEX Elementary Maths set			
79028	K'NEX Intermediate Maths set			
78650	K'NEX Discovery building set			
79520	K'NEX Simple machines deluxe set			
* Nett value of goods =				£

All orders are subject to our Terms and conditions, which may be found at:

<http://www.knexusergroup.org.uk/acatalog/tandc.html>

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