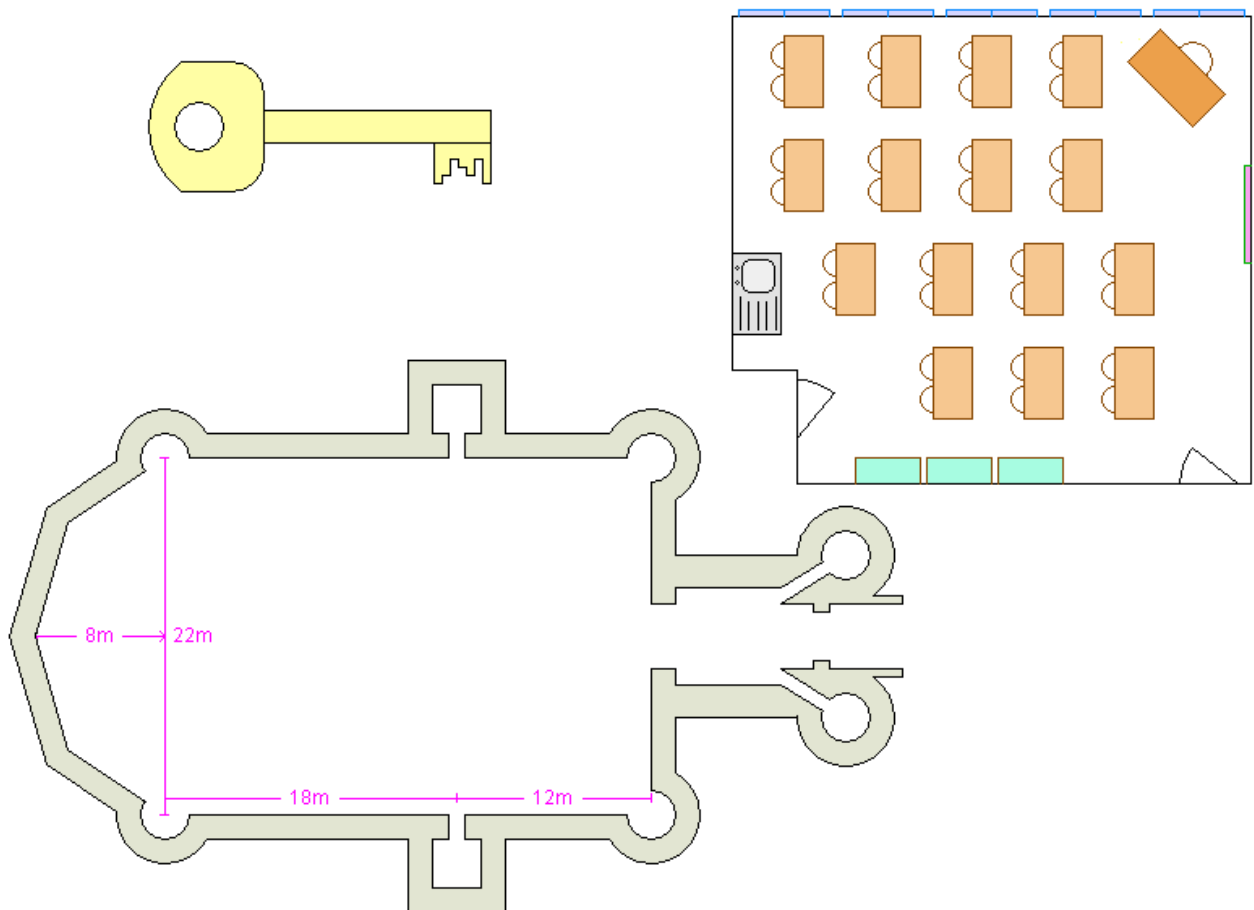


# Graphical Modelling with FlexiCAD 3



# Graphical modelling with FlexiCAD 3

## QCA Scheme of Work

The QCA Scheme of Work for ICT includes Unit 5A (graphical modelling). In this unit children learn to use an object-based graphics package to produce images and visual models. At the end of this unit:

<i>most children will:</i>	use an object-based graphics package to create, combine and manipulate objects and explore possibilities
<i>some children will not have made so much progress and will:</i>	use an object-based graphics package to create, combine and manipulate objects
<i>some children will have progressed further and will:</i>	use an object-based graphics package to create and explore an accurate graphical model checking predictions and make decisions

## Worksheets

This booklet contains seven worksheets. If they are used in the following order, pupils will be introduced to all the main features of the program, at the same time as meeting the expectations of the unit of work. Some pupils may only use the first three worksheets; most pupils will get as far as designing their classroom (worksheet 5). The last two worksheets provide some extension work for the more able. The seven worksheets are:

### 1. Getting started with FlexiCAD

Sets up a grid to aid accurate drawing; explains how to hold the mouse button down when drawing; introduces the **Line**, **New line**, **Corner**, **Fill** and **Text** tools.

### 2. The key to success

Uses a **Real world scale** so that distances correspond to the final object; introduces the **Arc** and **Circle** tools.

### 3. Mazes

Problem solving using a graphics package; pupils begin by solving two mazes, and then create their own maze; introduces the **Copy** and **Delete** tools.

### 4. Tessellations

Using a graphics package to create tessellations. The first three drawings involve progressively more complex starting shapes. Pupils are then asked to create their own starting shape.

### 5. Designing your classroom

Pupils are asked to measure their own classroom, and then use the results to draw the outline and any fixed furniture; introduces the **Move** and **Rotate** tools.

## 6. A fancy box

Using a graphics package to create a net which can then be cut out and stuck together to make a solid object; introduces the **Reflect** tool.

## 7. Donnington Castle

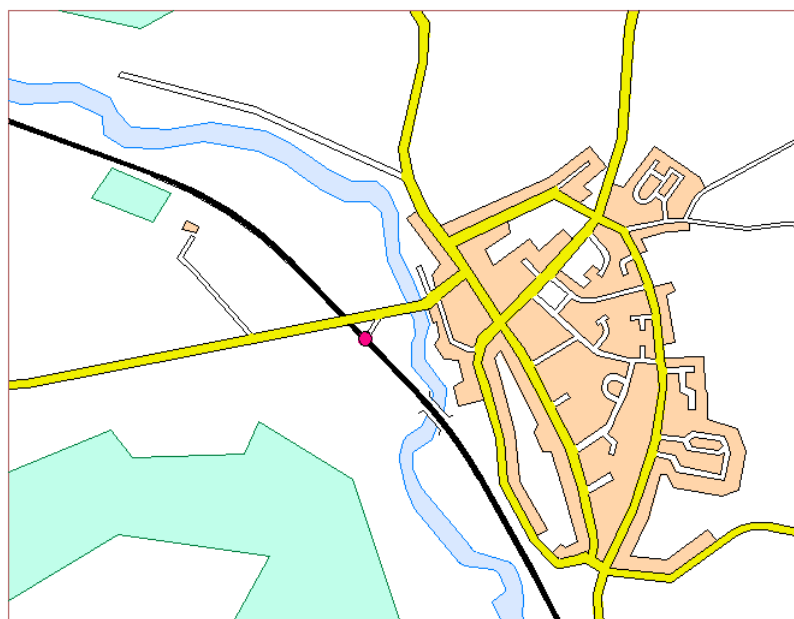
Drawing a plan of an existing building; introduces the **Break** tool; at the end of the worksheet pupils are asked to use the internet to carry out some historical research.

## Further extension work

Pupils could create a symbol library of items such as desks, chairs, cupboards, etc, which can then be used to plan the layout of the their classroom. Pupils could be asked to create a plan of some or all of the school grounds, based on actual measurements taken by the pupils. They can then be asked to redesign part of the outside space for a new project such as a wildlife area or a garden, perhaps using the symbol library. Pupils could be asked to produce a drawing based on shapes which tessellate, perhaps based on a work by Escher.

## Other subjects

The skills which are developed in this unit of work can be used in several other subject areas. In Mathematics it links closely with work on distance, scale, measurement, co-ordinates and angle, and also leads to work on tessellations, reflections and rotational symmetry. In Science pupils can use FlexiCAD to draw diagrams to show how apparatus was put together or how forces work. In Design & Technology, children can use the program to draw nets which can be cut out and made into solid objects; they can also produce accurate plans and scale drawings for models. In Art the program can be used to develop work on pattern – for example producing a motif which is then reproduced by rotation, translation, etc. In Geography pupils can use FlexiCAD to produce maps and plans.

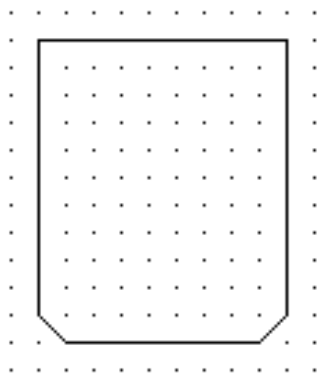
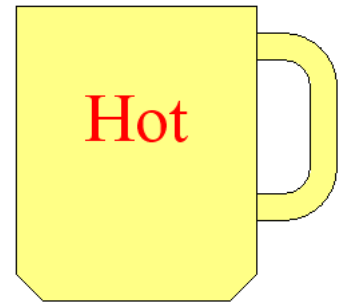


# 1. Getting started with FlexiCAD

This sheet explains how to use FlexiCAD to draw a mug.


1. Start FlexiCAD. Use the **View | Grid settings** command to switch **Snap to Grid** on and choose **Dots** (instead of **Lines**).

From now on all the points you choose will be locked onto the grid which will make drawing much easier.



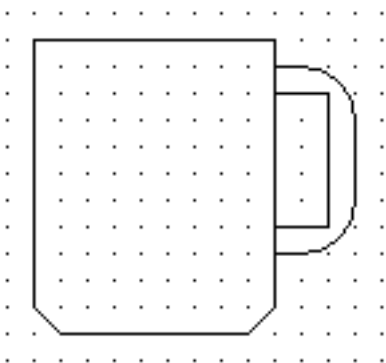
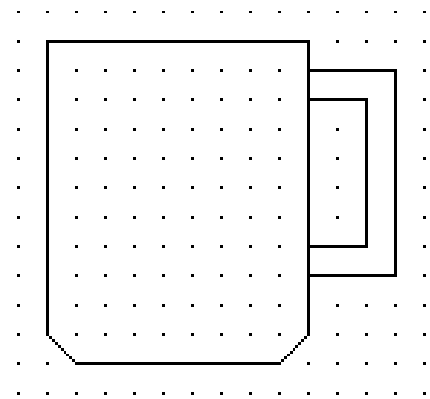
**Drawing the outside of the mug.** Notice that the top edge is 8cm across and the sides are 10cm down.

2. Click in the middle of the screen to start the first line.
3. **Hold the left mouse button down** and move the mouse until the first line is the right length and direction - then let go of the mouse button.
4. Hold the mouse button down again to draw the next line.

If you make a mistake, click on  the **Undo** tool in the toolbar at the top of the screen.

**Drawing the handle.** You will need to start a new line which is not joined to the end of the previous line.

5. Click on the **New line** tool in the toolbox at the right hand side of the screen.
6. Hold the mouse button down, move the mouse until the cross is at the start of the outside edge of the handle and then let the mouse go.
7. Draw the three lines which make up the outside of the handle.
8. Now choose **New line** again and then repeat these steps for the inside of the handle.

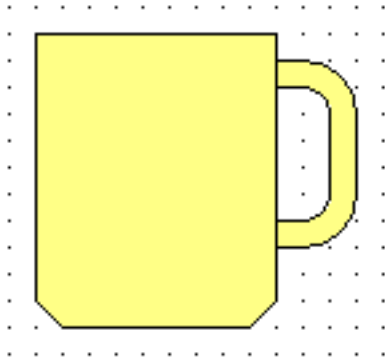


**Making the handle curved.** Each of the four corners in the handle needs to be changed to a curve.

9. Click on the **Corner** tool in the toolbox and, when the sub-menu appears, click on **Fillet**.
10. At the bottom of the screen, click inside the radius box, type **20mm** and then press the **Enter** key.
11. Move the mouse until it is near the top outside corner of the handle and then click the mouse button.
12. Repeat this for the bottom outside corner of the handle.

## Finishing off the handle.


13. Click inside the radius box again, type **10mm** and then press the **Enter** key.
14. Move the mouse until it is near the top inside corner of the handle and then click the mouse button. Repeat this for the bottom inside corner of the handle.

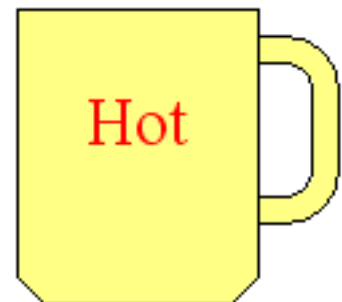


## Filling the mug with colour.

15. Click on the **Fill** tool in the toolbox.
16. At the bottom of the screen, click inside the colour box, choose yellow from the possible colours and then click on **OK**.
17. Use the mouse to point anywhere inside the mug and click the mouse button.
18. Use the mouse to point anywhere inside the handle and click the mouse button.

## Putting your message on the mug.

19. Click on the **Text** tool in the toolbox.
20. At the bottom of the screen, click inside the font box. Choose your own font, and make the font size between 36 and 72 (depending on how long your message is going to be).
21. At the bottom of the screen click in the colour box and choose red.
22. Use the mouse to point inside the mug where you want the top left of the text to be and click the mouse button.
23. Type your message and then press **Enter**.
24. If the text is not in the right place, click on the **Move** tool in the toolbox and then choose **Move an item**. Now point somewhere inside your text, hold down the mouse button and drag the text to the position you want. If the screen needs cleaning after this, then click on  the **Redraw** button in the toolbar.



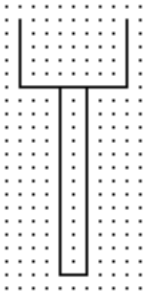
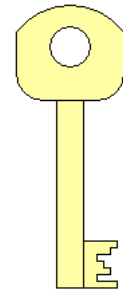
## 2. The key to success

This sheet explains how to use FlexiCAD to draw a key.

1. Start FlexiCAD, and choose the **View | Grid settings** command. You should switch **Snap to Grid** on and choose **Dots**.

Since the key is only about 4cm long, we need to change the scale.

2. Choose the **Edit | Real world scale** command and choose a value of **0.2**. This will have the effect of making each point on the grid 2mm apart.

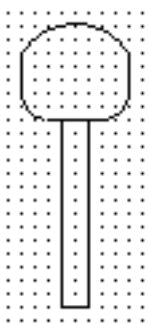
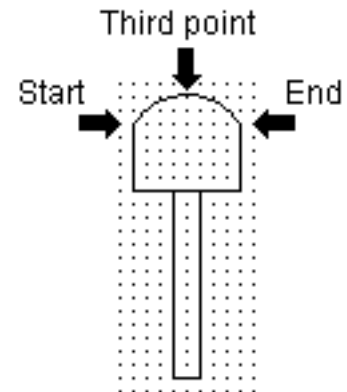


### Drawing the handle and shank of the key.

3. Click in the middle of the screen to start the handle of the key.
4. Draw the three lines that make up the handle of the key (which is 5 grid points down and 8 grid points across - 10mm by 16 mm).
5. Click on the New line tool in the toolbox.
6. Draw the three lines that make up the shank of the key (which is 14 grid points down and 2 grid points across - 28mm by 4mm).

**The top of the handle.** The top of the key is an arc (part of a circle). In FlexiCAD you can draw an arc by choosing the start point, the end point and one other point on the arc.

5. Click on the **Arc** tool in the toolbox at the right hand side of the screen.
6. Hold the mouse button down, move the mouse until the cross is at the top left of the handle and let go of the mouse button.
7. Hold the mouse button down, move the mouse until the cross is at the top right of the handle and let go of the mouse button.
8. Hold the mouse button down, move the mouse until the arc is in the right position (the radius will be approximately 10mm) and let go of the mouse button.

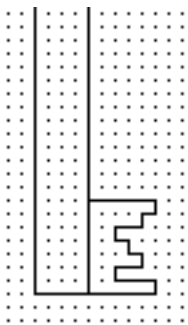
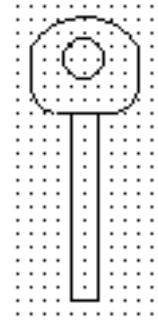


**Making the handle curved.** The two bottom two corners of the handle need to be changed to curves.

9. Click on the **Corner** tool in the toolbox and, when the sub-menu appears, click on **Fillet**.
10. At the bottom of the screen, click inside the radius box, type **4mm** and then press the **Enter** key.
11. Move the mouse until it is near the bottom left corner of the handle and then click the mouse button.
12. Repeat this for the bottom right corner of the handle.

**Putting a hole in the handle.** The hole is a circle. In this case we are going to choose the radius of the hole and then choose the position of the centre.

13. Click on the **Circle** tool in the toolbox at the right hand side of the screen.
14. At the bottom of the screen, click inside the radius box, type **3mm** and then press the **Enter** key.
15. Hold the mouse button down, move the mouse until the circle is in the right position and then let go of mouse button.

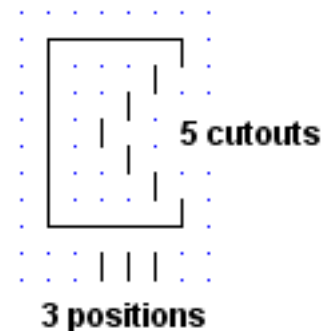


**Adding the pattern to the key.** The detail of the pattern is too fine to draw with the current grid. The first step is to change to a finer grid.

16. Choose the **View | Grid settings** command. You should choose grid size of **1mm** and then click on **OK**.
17. Click on the **New line** tool in the toolbox at the right hand side of the screen.
18. Draw the pattern at the bottom of the shank of the key which consists of fourteen lines.

The pattern on this key has five places that can be cut out, and each of these cutouts can be in one of three positions. Each of the cutouts has to match with its own lever inside the lock if the key is to turn.

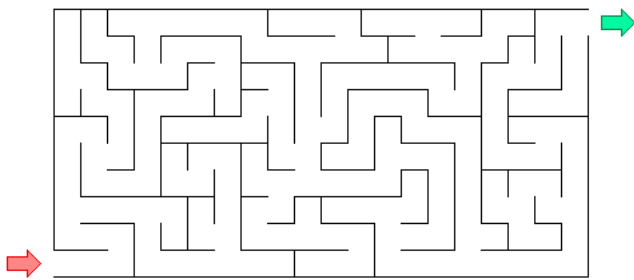
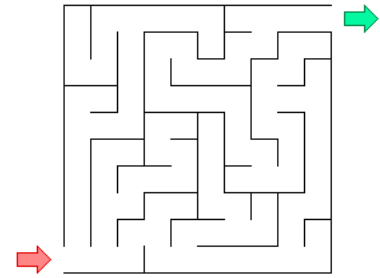
19. Draw another key, but with a different pattern of cutouts. If you wish you can copy the handle and shank of the original key using the **Copy** tool and then draw the pattern.
20. Work out how many different keys can be made using this pattern.



### 3. Mazes

This sheet explains how to use FlexiCAD to draw mazes. To start, see if you can solve this maze, using FlexiCAD to draw your answer path.

1. Start FlexiCAD, use the **File | Open** command, click on the **Samples** button and load the file **Maze1**.
2. Use the **View | Grid settings** command, and switch **Snap to Grid** on, choose **Dots** and choose a **Grid size** of **10mm**.
3. Choose a red colour, and then draw your answer on the maze. If you make a mistake you can use the **Undo** tool.

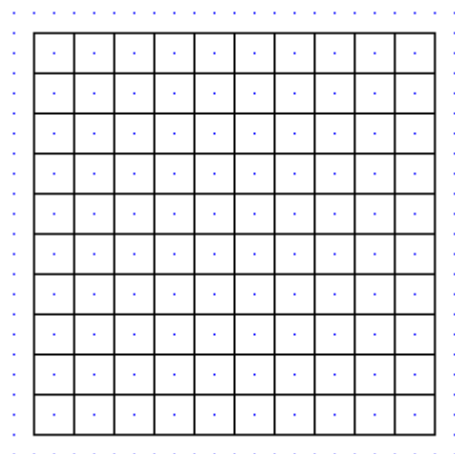


Now try to solve a more difficult maze - this one is 20 squares by 10 squares.

4. Use the **File | Open** command, click on the **Samples** button and load the file **Maze2**. Choose a red colour, and then draw your answer on the maze.

**Making your own maze.** There are several ways to make the maze. One method is to draw the complete framework, then draw your answer path from beginning to end, and finally rub out lines to leave the maze. Note that when you draw the framework, the lines are 20mm apart so that you can draw your answer using FlexiCAD's grid system.

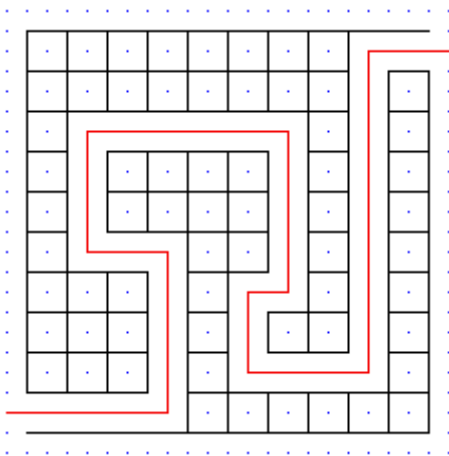
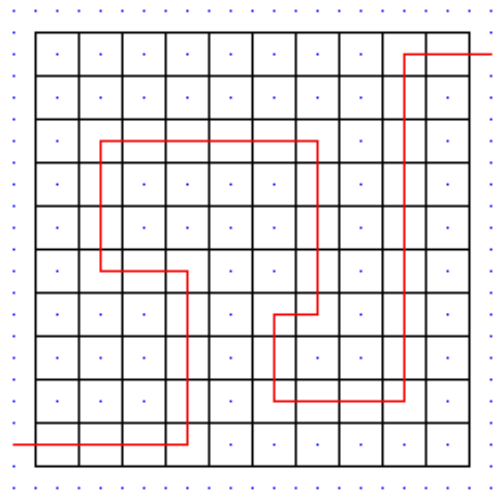
5. Use the **File | New** command. Click in **Object:** at the bottom of the screen and type **Maze**.
6. Draw four 20mm lines to make a square near the bottom left of the screen.
7. Click on the **Copy** tool. At the bottom of the screen, click in the **Number of copies:** and type **9**; click in the **New objects:** box and select **No**.
8. Click on the top, right and bottom sides (but NOT the left hand side) of the square.
9. Click on the **Copy the selected items** button. Use the mouse to point to the bottom left grip, hold the mouse button down and then drag the lines 20mm to the right.
10. Repeat the last three steps, this time clicking on all the top and side lines (but NOT the bottom lines), and drag the copies 20mm upwards.





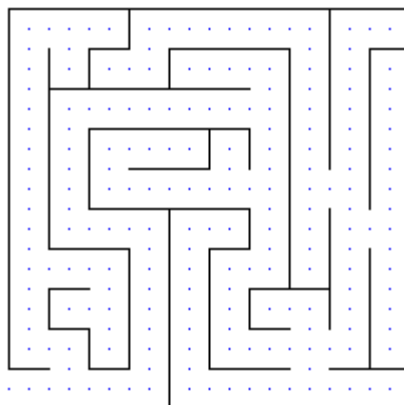
**Making your own maze.** Now draw in your own path from the start to the end. It is important to make this a different object so that you can delete it easily once you have finished the maze.

11. Click in **Object:** at the bottom of the screen and type **Answer**.
12. Click on the **New line** tool. Click in **Colour:** and choose red. Now draw your path through the maze from start to end. The line you draw must not cross over itself or else you will create a shortcut.



13. Click on the **Delete** tool.
14. Click on each of the lines in the framework which cross the path you have just drawn. Click on the **Delete the selected items** button.

15. Keep repeating the last step to delete other lines to create paths that look like they might be a way out of the maze, but be careful to not actually connect these paths back to your answer!
16. Finally, click on **Answer** in the list of objects and delete the answer itself.

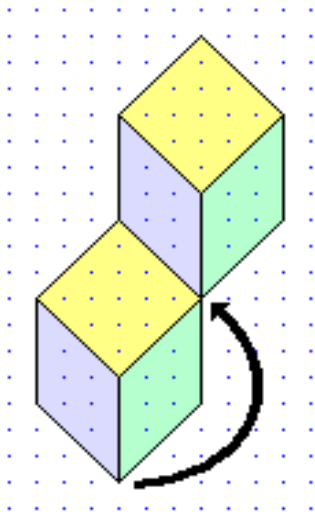
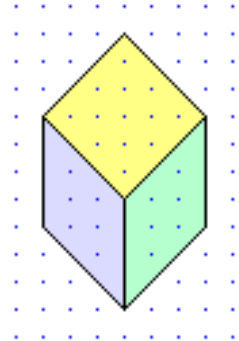


Now use the same method to create a 20 by 10 maze of your own and then print it out. See if your friends can solve your maze.

## 4. Tessellations

A tessellation is any pattern which is made from repeating a shape in both directions so that it fills all the available space.

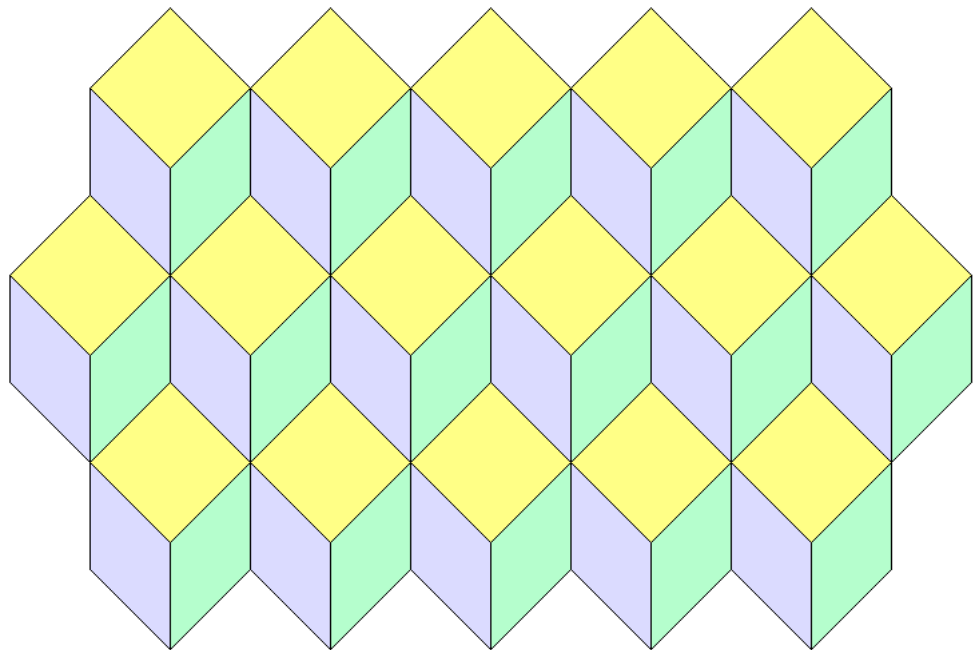
1. Start FlexiCAD, use the **View | Grid settings** command, and switch **Snap to Grid** on, choose **Dots** (instead of **Lines**).
2. Draw the lines which make this simple shape.
3. Use the **Fill** tool to fill each of the three quadrilaterals with a different colour.



Now copy this simple shape.

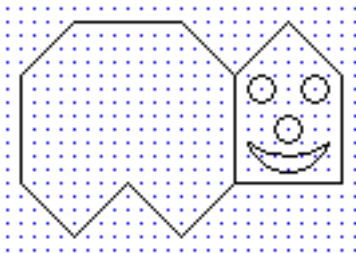
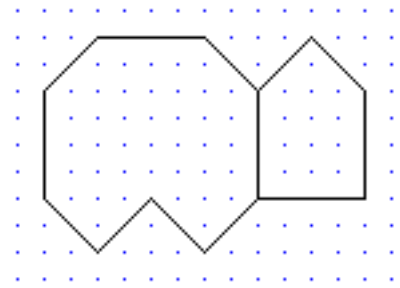
4. Click on the **Copy** tool. Click on the object in the list of objects. Click on **Copy the selected items** button at the bottom of the screen. A grey square 'grip' will appear around each of the points.
5. Use the mouse to point to the bottom centre grip, hold the mouse button down and drag the first copy and to the right. When it is in the correct position let go of the mouse button.
6. Repeat the last step to make the following pattern.

When you look at this pattern, can you see a series of cubes, stacked on top of each other?



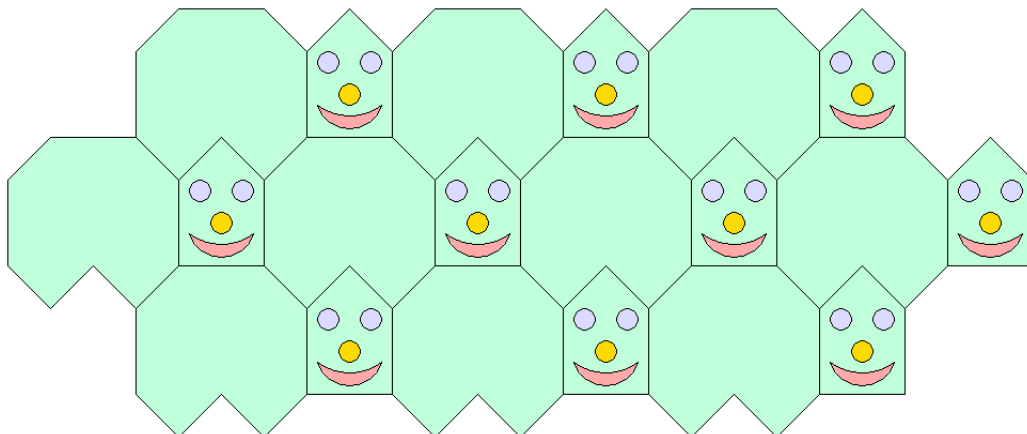
**Making a shape that tessellates.** This exercise shows how a quite complex shape can be made to tessellate. In this case, we can make a caterpillar tessellate.

5. Use the **File | New** command to clean the screen and reset the drawing.
6. Draw the lines which make this simple caterpillar. It is important that you do not change the size or shape or your caterpillar might not fit with the next one.

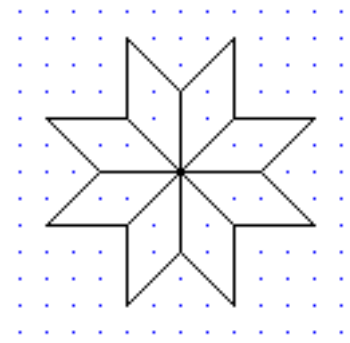


7. Use the **View | Grid settings** command and choose a grid size of **5mm** and then click on **OK**.
8. Draw the eyes, nose and mouth of your caterpillar. The radius of each of the three circles is 5mm. The mouth is made from two arcs.
9. Use the **Fill** tool to fill the body with a light green colour, blue for the eyes, yellow for the nose and red for the mouth.

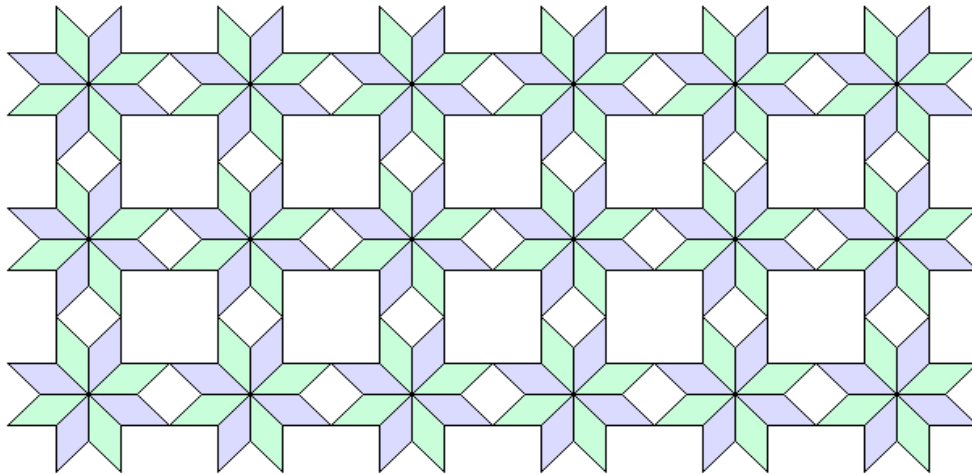
10. Click on the **Copy** tool. Click on the object in the list of objects. Click on the **Copy the selected items** button at the bottom of the screen.
11. Use the mouse to point to the bottom of the back leg, hold the mouse button down and drag the copy until its back leg is on the neck of the first caterpillar.
12. Repeat the last step to make the following pattern.



13. Use the **File | New** command to clean the screen and reset the drawing.
14. Draw the lines which make this shape. You can either draw all of the lines, or else draw one of the diamonds, reflect it to get two adjacent diamonds and then rotate both of them by  $90^\circ$  three times to get all eight diamonds.
15. Use the **Fill** tool to colour in the shapes to a pattern of your choice.

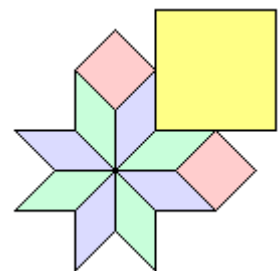


16. Click on the **Copy** tool. Click on the object in the list of objects. Click on the **Copy the selected items** button at the bottom of the screen.
17. Use the mouse to point to one of the grips and move the copy to the next position.
18. Repeat the last step to make the following pattern.



In this tessellation, the shape needed to fill the whole space is this one:

19. Try to design your own shape which will tessellate and use FlexiCAD to produce a pattern to show the tessellation.

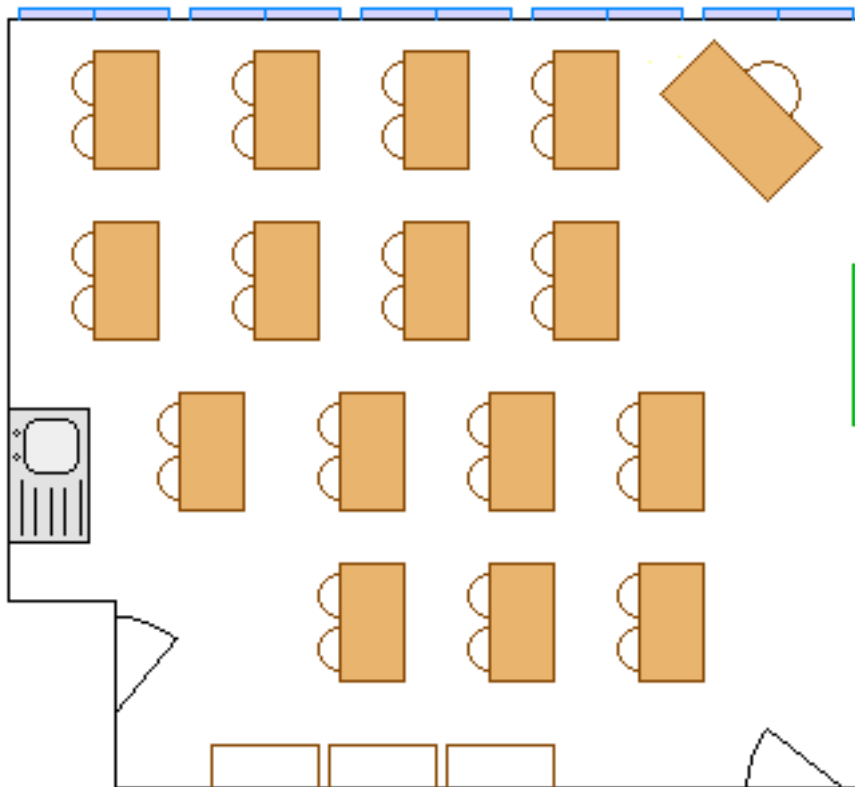




## 5. Designing your classroom

This sheet explains how to use FlexiCAD to design your classroom. The first step is to measure your classroom and each of the main objects in the room that can be moved, such as desks, trolleys, etc. Measure things to the nearest 10cm. Once you have all the measurements, we will use FlexiCAD to draw the outline of the classroom and then move the desks around inside this room.

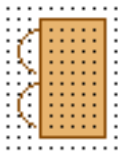
1. Start FlexiCAD and use the **Options | Preferences** command. Choose the **Values** tab and then set the **Display units** to **Automatic**. This will show large distances in metres and smaller distances in centimetres.
2. Use the **Edit | Real world scale** command and choose a value of **50**. Use the **View | Grid settings** command, and switch **Snap to Grid** on, choose **Dots** and choose a **Grid size** of **10cm**.



### Drawing the classroom.

3. Click in the top left of the screen and then draw each of the walls, one after another. If the measurements are all to the nearest 10cm you will be able to fix the end of each line on the grid. You should get back to where you started if your measurements add up.
4. You can show a door as a line and an arc. This is useful to remind you to leave enough space around each doorway.
5. Now draw any fixed items such as radiators, sinks, benches, etc.
6. In the drawing above the windows are shown outside the room to remind you where they are even though they don't use any floorspace. The whiteboard is shown inside the room.

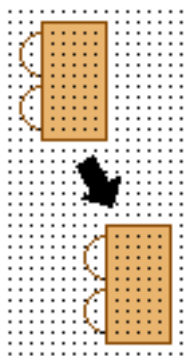
**Draw the objects that can be moved.** You need to draw one of each of the objects that can be moved, such as the desks and chairs, teacher's desk, trolleys, etc. Once you have drawn them, you can make as many copies as you need for your classroom and then move them about. You can also rotate them if required.



7. Click in the **Object:** box at the bottom of the screen, type **Desk** and then press **Enter**. Now draw a desk using your measurements (the one on the left is 110cm by 60cm).
8. The two chairs are represented by arcs - click on the **Arc** tool, choose an angle of 180° and then add the two arcs. If you wish, use the **Fill** tool to colour the inside of the desk.
9. If there are any other size desks (such as the teacher's desk) or cupboards that can be moved, then draw one of each. Remember to type the name of each object just before you start to draw it.
10. Use the **File | Save** command to save the classroom and the movable items on disk.

**Planning the layout.** When you plan the layout of your classroom, you need to think about several factors. For example do all the desks need to face the same way so that you can see the blackboard or whiteboard? Can the teacher move about easily between the desks? Is there enough space to allow doors to open properly? Is there enough space around trolleys and sinks?

Once you have an idea about how you want the layout to appear, you can use FlexiCAD to move things about.



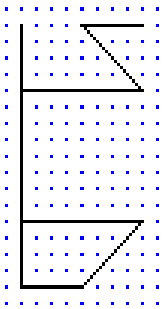
10. Click on the **Copy** tool. Click on **Desk** in the list of objects. Make sure that the **New objects:** box is set to **Yes**.
  11. Once the desk is selected, click on the **Copy the selected items** button at the bottom of the screen. A grey square 'grip' will appear around each of the points on the desk.
  12. Use the mouse to point to a grip, hold the mouse button down and then drag the copy of the desk to the position you want and then release the mouse button.
  13. Repeat the last step until you have enough desks, cupboards etc for your classroom.
14. Use the **Move | Move items** tool to move any of the objects such as a desk or a cupboard. You can use the **Rotate** tool to rotate any of the objects. The angle of rotation is anticlockwise. Once your classroom is the way you want it be, use the **File | Save as** command with a different filename and then print your classroom using the **File | Print** command.
  15. Now load your original classroom and try to produce a completely different layout. Write down the advantages (and disadvantages) of each of your two layouts.

## 6. A fancy box

This sheet explains how to use FlexiCAD to draw the **net** for a box. A net is a flat version of a solid object which you can cut out and fold into the object, often with tabs that you glue down to help make the object. In this case, the object is a box with a special top. You can also use FlexiCAD to decorate the box before you print it.

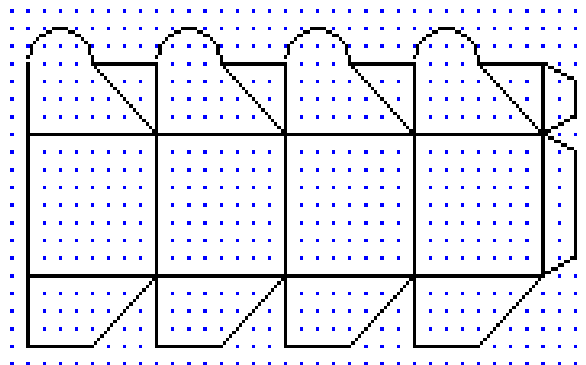
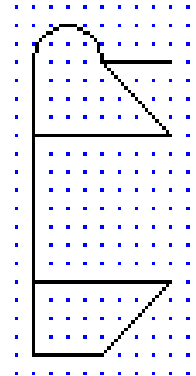
1. Start FlexiCAD and use the **View | Grid settings** command, switch **Snap to Grid** on and choose **Dots**.

**Drawing the net.** The net of this box is shown at the bottom of this page.



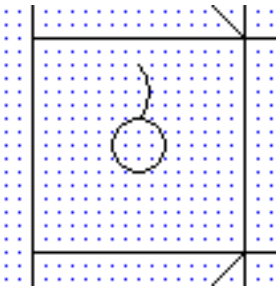
2. Draw this shape. You will need to click on the **New line** tool each time you want to start a line which is not connected to the previous line.

3. Click on the **Arc** tool and then choose an angle of  $180^\circ$ . Add the two arcs that are in this shape. The arc will go anti-clockwise from the start to the end point.
4. Click on the **Copy** tool. Choose the **Number of copies** to be **3**. Click on the object in the list of objects. Once the lines are selected, use the mouse to click on **Copy the selected items** button at the bottom of the screen. A grey square 'grip' will appear around each of the points.
6. Use the mouse to point to the bottom left grip, hold the mouse button down and then drag the first copy 80mm to the right.
7. Click on the **New line** tool and draw the two tabs at the right hand side of net.



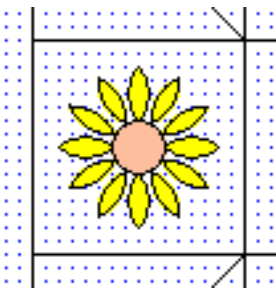
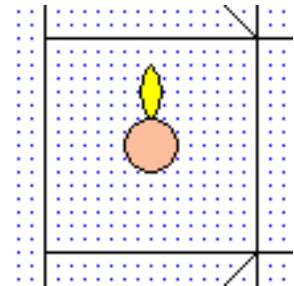


**Decorating the box.** You can use FlexiCAD to decorate your box before it is printed. The following is a suggestion for a flower, but you can design your own decorations if you wish.



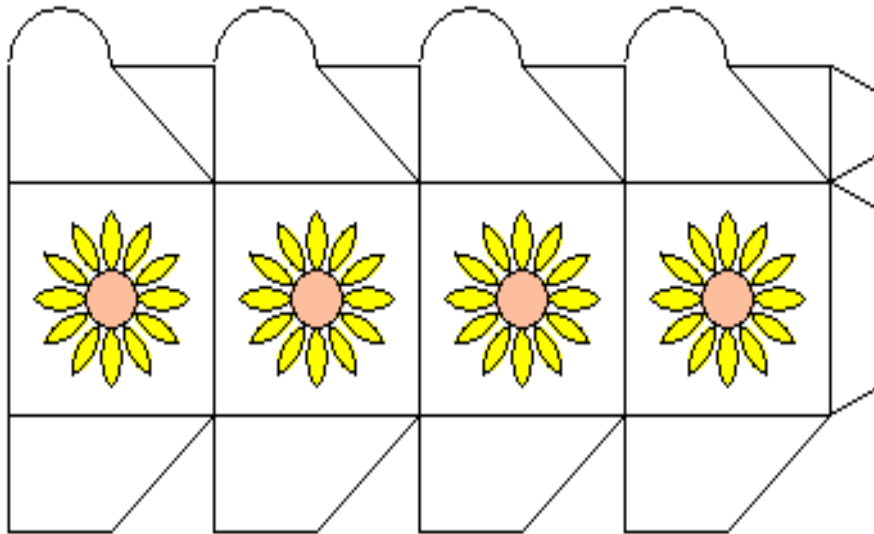
7. Use the **View | Grid settings** command and choose a **Grid size** of 5mm.
8. Click in the **Object:** box at the bottom of the screen and type **Flower**.
9. Click on the **Circle** tool, and draw a circle with a radius of 10mm in the centre of the left-most square.
10. Click on the **Arc** tool, and draw an arc from the top of the circle to a point 20mm above it, with an angle of approximately 80°.

11. Click on the **Reflect** tool and then click on the arc to select it. Click in the **Keep originals:** box and select **Yes**. Click on the **Reflect the selected items** button at the bottom of the screen, and move the mouse so that the mirror line is through the centre of the circle and click the mouse button.
12. Click on the **Fill** tool and fill the petal and the centre of the circle with two light colours such as yellow and orange.



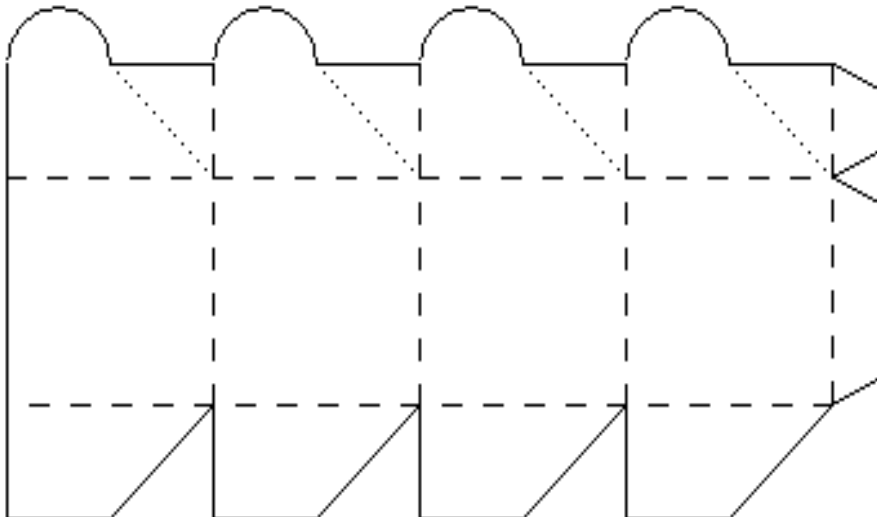
13. Click on the **Rotate** tool. Click in the **Angle of rotation:** box and type **30**; click in the **Number of actions:** box and type **11**; click in the **Keep originals:** box and select **Yes**; if necessary, click in the **New objects:** box and select **No**.
14. Click on the two arcs and the petal fill to select them. Click on the **Rotate the selected items** button at the bottom of the screen, move the mouse so that the centre of rotation is the centre of the circle and click the mouse button.

15. Click on the **Copy** tool. Choose the **Number of copies** to be **3**. Click on **Flower** in the list of objects. Click on **Copy the selected items** button at the bottom of the screen. A grey square 'grip' will appear around each of the points on the flower.
16. Use the mouse to point to the grip in the centre of the circle, hold the mouse button down and then drag the three copies 80mm to the right.



### Making the box.

17. Use the **File | Print** command to print the net. If possible, stick the paper to a piece of card which will make the box much stiffer. Cut out around the outside edge. The two bottom two corners of the handle need to be changed to curves.
18. Fold along all the remaining lines. In the drawing below the dashed lines are folded as outside edges, while the dotted lines are folded as inside edges.



19. Fold the four sides round and glue the two tabs inside the edges that they meet. If you want, you can also glue down the four squares at the bottom to make the base of the box more solid.

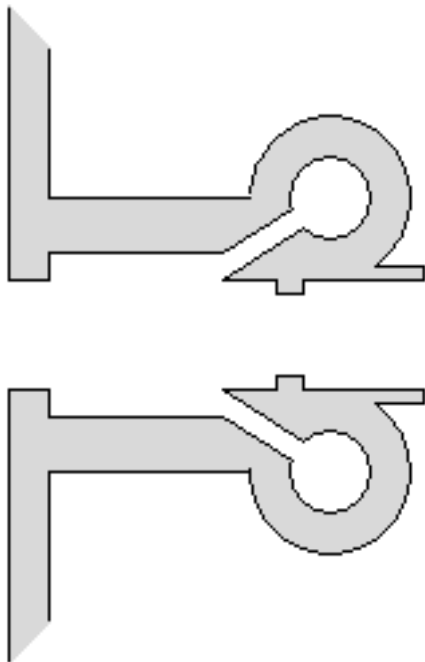


## 7. Donnington Castle

Donnington Castle in Berkshire was built in the 14th century by a knight called Richard de Abberbury. He was given permission to build the castle by the king, Richard II. It was probably made by adding a very strong gatehouse onto an existing fortified house. Only the gatehouse still remains - the ruins of the rest of the castle walls are now just a few centimetres high.

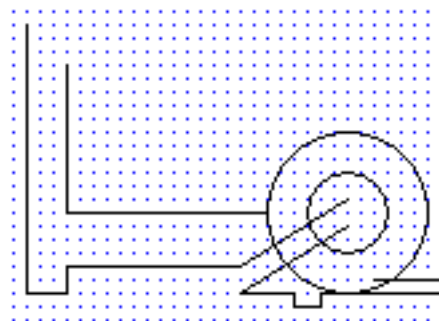
This sheet explains how to use FlexiCAD to draw a plan of the castle.

1. Start FlexiCAD, choose the **Edit | Real world scale** command and choose a value of **100**.
2. Choose the **View | Grid settings** command. You should switch **Snap to Grid** on, choose **Dots** and choose a **Grid size** of **50cm**.



**Drawing the gatehouse.** Notice that the gatehouse is symmetric, so you only need to draw the top half and then reflect it.

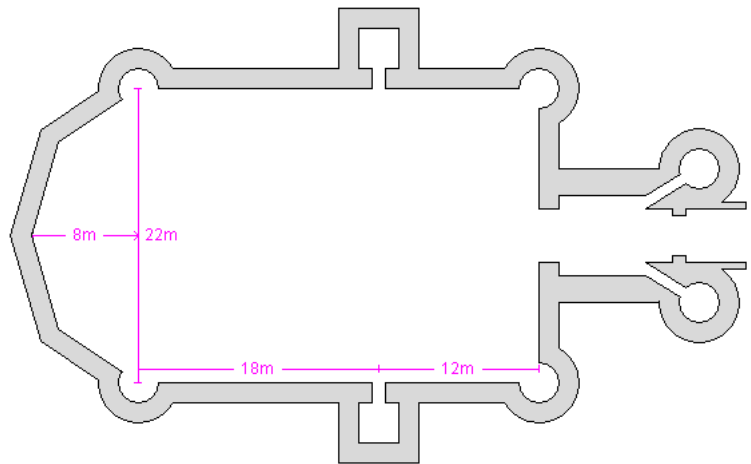
3. Start by drawing the back wall, the two circles that make the tower and the side wall. At this stage don't worry about joining the side wall to the tower - draw the lines as they appear in the drawing below.



4. Now click on the **Break** tool. Click on one of the lines which is too long, and you will be asked to choose which sections of that line are to be deleted. Repeat this for the other two lines which cross the circles. Finally, click on each of the circles and delete the sections which are not needed.
5. Use the **Reflect** tool to add the other half of the gatehouse to your drawing. Note that the mirror direction is horizontal. The width of the front opening is 4m.

**Drawing the rest of the castle.** The rest of the castle is also symmetric, so you only need to draw the top half and then reflect it.

6. Start by drawing the two circular towers (which are the same size as the towers in the gatehouse). Then draw the long wall, along with the square tower (which is 3m by 3m inside, and the doorway is 1m wide). Finally draw the two diagonal walls - you can estimate their position.
7. Use the **Break** tool to trim the lines and circles, the **Reflect** tool to add the other half of the castle, and the **Fill** tool to fill in the grey shading.



8. Find out the names of the parts of a castle, and use them to label your drawing.



Here is a view of the other side of the gatehouse, looking across the ruins of the rest of the castle.

9. Can you work out how many floors were in the main part of the castle?

10. Use the internet to find out what happened to Donnington Castle.