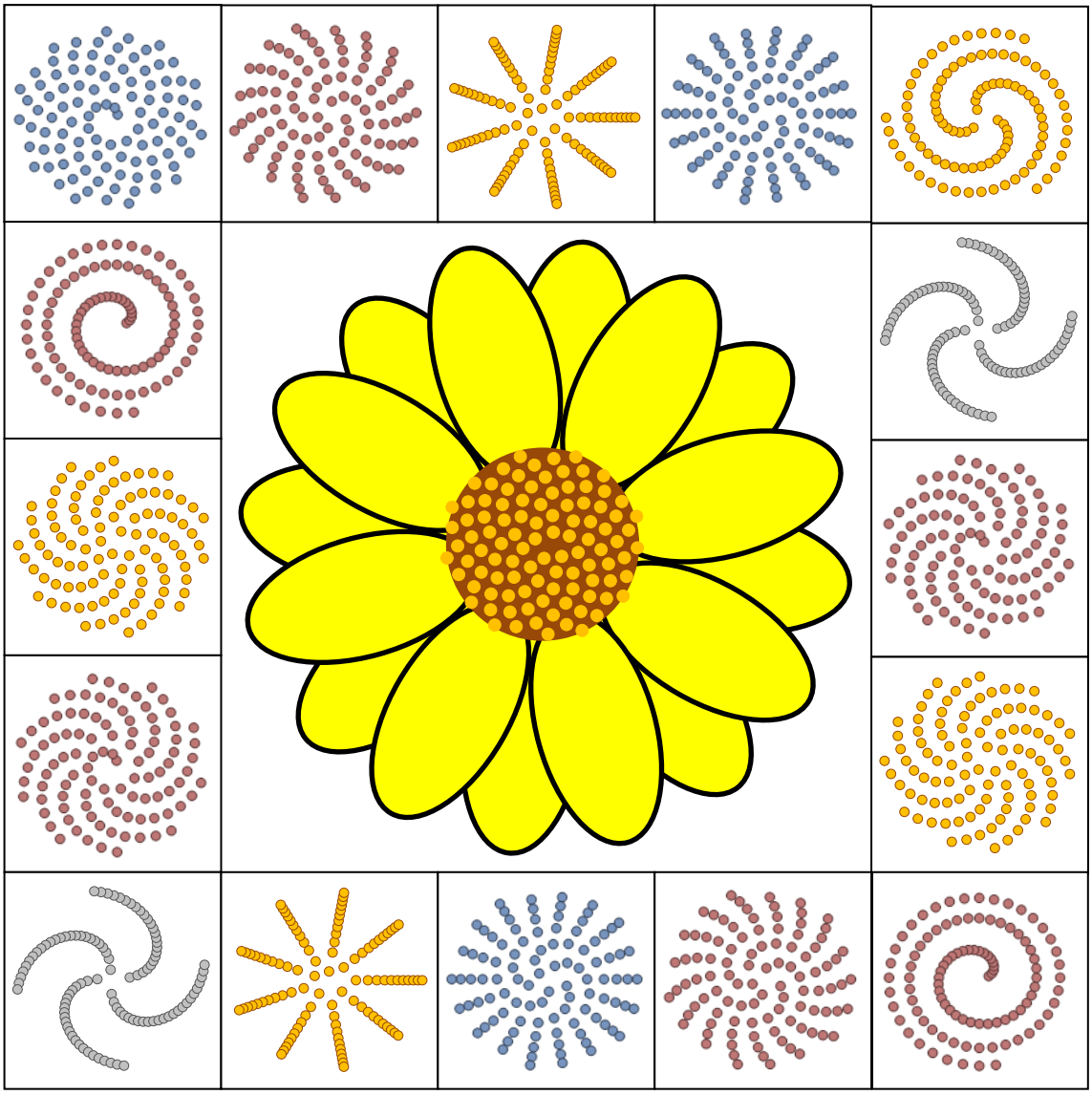
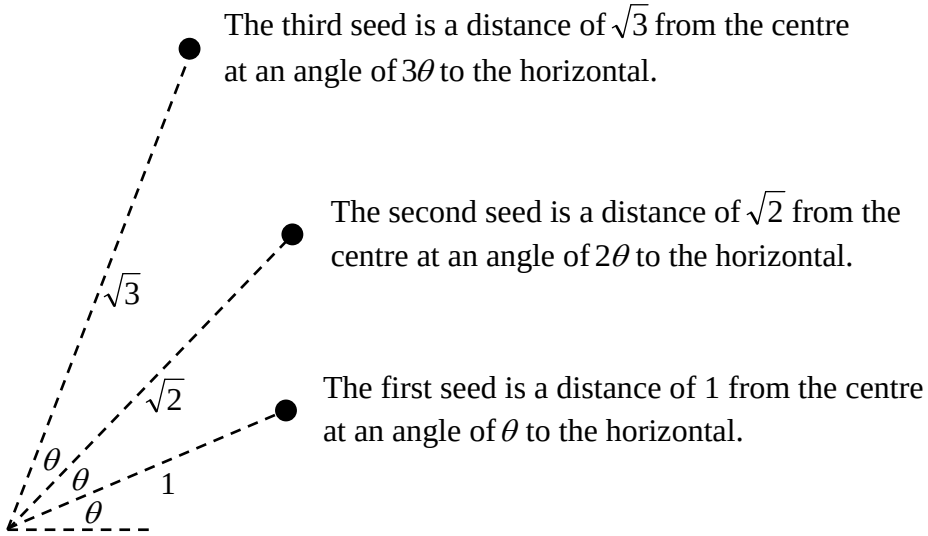
How do Flowers Grow?



The seeds in the centre of a flower are arranged using the following rule:



The n^{th} seed is a distance of $\sqrt{n}$ from the centre at an angle of $n\theta$ to the horizontal.

Task 1

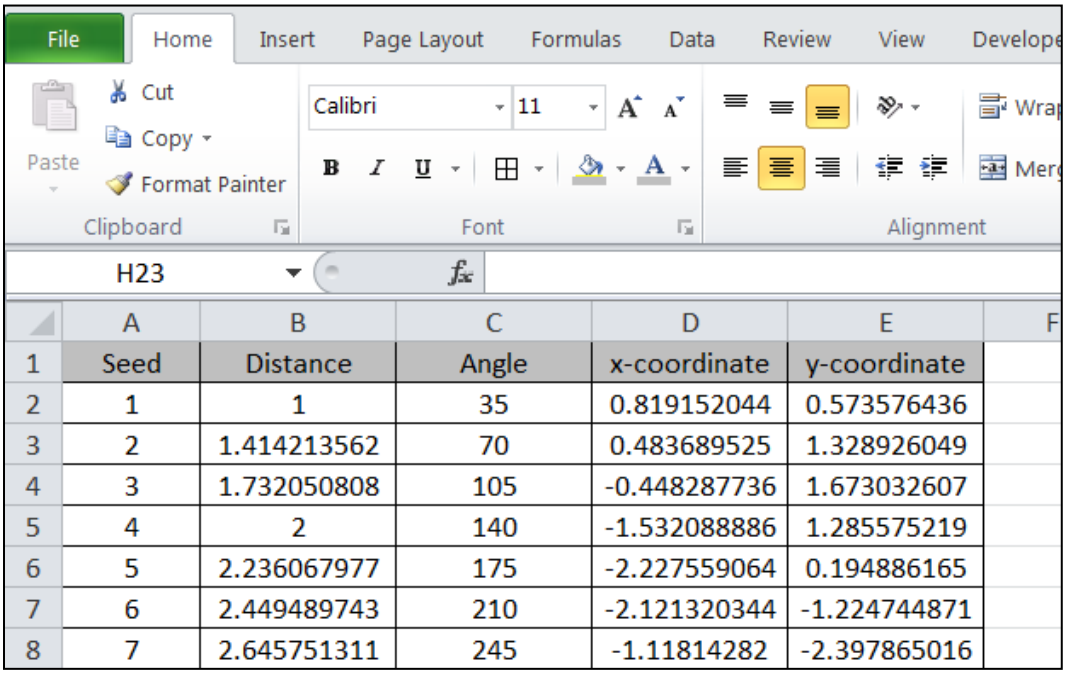
Using Excel investigate different values of θ to determine which value *appears* to give the most evenly spaced seeds (use your own judgement) . Use values of θ which are multiples of 0.5 and between $0°$ and $180°$. Display 1000 seeds in your spreadsheet.

Setting up your Spreadsheet

Your spreadsheet should contain five columns. Use a separate cell to store the value of θ . You should only have to enter formulae into the first two rows of the spreadsheet. If the second row is correct it can be copied and pasted to all of the other rows.

Use the screenshot below to determine the accuracy of your sheet. When using trigonometric functions in Excel you need to first convert degrees into radians using the RADIANS() function. For example =COS(RADIANS(C3)) will convert the contents of cell C3 into radians and then calculate its cosine.

To create your diagrams simply use the x and y coordinates to create a scatterplot.



	A	B	C	D	E	F
1	Seed	Distance	Angle	x-coordinate	y-coordinate	
2	1	1	35	0.819152044	0.573576436	
3	2	1.414213562	70	0.483689525	1.328926049	
4	3	1.732050808	105	-0.448287736	1.673032607	
5	4	2	140	-1.532088886	1.285575219	
6	5	2.236067977	175	-2.227559064	0.194886165	
7	6	2.449489743	210	-2.121320344	-1.224744871	
8	7	2.645751311	245	-1.11814282	-2.397865016	

Task 2

For various values of θ , including the one you found to produce the most evenly spaced seeds, perform the following:

- For every seed determine the distance to the closest seed.
- Calculate the mean and the standard deviation of these distances.

Do your results support the value of θ you found in the previous task? (It is okay if they don't). Explain your reasoning. Use your spreadsheet to give a more accurate value of θ to three decimal places.

Create a report of your work. The word limit is 1000. Be sure to include

- an explanation of how the seeds are arranged (include an explanation of why we only need to investigate values of θ between $0°$ and $180°$)
- an explanation of all unique equations in the first two rows of your spreadsheet models
- the results and conclusions of your investigation for task 1
- the results and conclusions of your investigation for task 2

Hints for Task 2

To complete this task you will need to consider each seed one-by-one and calculate the distance to every other seed. Then you will have to find the minimum of these values. This means you will need to use at least 1000 columns and 1000 rows.

Be careful when calculating the distance from one seed to every other seed. If you calculate the distance to the same seed then this value will be zero. Use an IF statement to avoid this problem.

Functions you may find useful are: SQRT, IF, INDIRECT, MIN, AVERAGE, STDEV.P

Since this is a summative task no more hints can be provided for task 2. All work must be individual and you should not ask questions to your classmates.

It is possible to get a level 6 on task 2 just by explaining how you would use a spreadsheet to complete the task, without actually creating the spreadsheet (check the rubric).

Criterion C: Communication in Mathematics		
Achievement Level	Level Descriptor	Task Specific Clarification
0	The student does not reach a standard described by any of the descriptors below.	
1 – 2	The student is able to: I. **use** limited mathematical language II. **use** limited forms of mathematical representation to present information III. **communicate** through lines of reasoning that are difficult to interpret.	The student is able to: ○ explain how the seeds are arranged ○ use Excel to create diagrams of seeds for various values of θ
3 – 4	The student is able to: I. **use** some appropriate mathematical language II. **use** different forms of mathematical representation to present information adequately III. **communicate** through lines of reasoning that are able to be understood, although these are not always clear IV. adequately **organize** information using a logical structure.	The student is able to: ○ clearly explain how the seeds are arranged using explanations and diagrams ○ use Excel to appropriately format diagrams (choose appropriate scales for the axes, hide axes, format data points) ○ take screenshots of Excel for use in the report ○ include diagrams showing the arrangement of the seeds for various values of θ
5 – 6	The student is able to: I. usually **use** appropriate mathematical language II. usually **use** different forms of mathematical representation to present information correctly III. move between different forms of mathematical representation with some success IV. **communicate** through lines of reasoning that are clear although not always coherent or complete V. present work that is usually **organized** using a logical structure.	The student is able to: ○ attempt to discuss whether the mean and standard deviation of the closest seed give us a good indication of whether the seeds are evenly spread out ○ attempt to explain why we only need to consider values of θ between $0°$ and $180°$
7 – 8	The student is able to: I. consistently use appropriate mathematical language II. use different forms of mathematical representation to consistently present information correctly III. move effectively between different forms of mathematical representation IV. communicate through lines of reasoning that are complete and coherent V. present work that is consistently organized using a logical structure.	The student is able to: ○ thoroughly discuss whether the mean and standard deviation of the closest seeds give us a good indication of whether the seeds are evenly spread out ○ make good use of space on the page (no unnecessary white space etc.) ○ use the equation editor for all equations and expressions ○ clearly and accurately explain, along with the use of mathematics and/or diagrams, why we only need to consider values of θ between $0°$ and $180°$ ○ save the report as a pdf file so that it looks consistent on different computers ○ celebrate the beauty of mathematics by creating at least one *flower* diagram

Criterion B: Investigating Patterns		
Achievement Level	Level Descriptor	Task Specific Clarification
0	The student does not reach a standard described by any of the descriptors below.	
1 – 2	The student is able to: I. **apply, with teacher support**, mathematical problem-solving techniques to discover **simple patterns** II. **state predictions** consistent with patterns.	The student is able to: ○ calculate the x and y coordinates of the first few seeds for various values of θ ○ determine an expression for the x and y coordinates of the n^{th} seed
3 – 4	The student is able to: I. **apply** mathematical problem-solving techniques to discover **simple patterns** II. **suggest general rules** consistent with **findings**.	The student is able to: ○ explain all unique equations used in the first two rows of the Excel sheet for task 1 ○ investigate various values of θ and determine a value which appears to give the most evenly spaced seeds
5 – 6	The student is able to: I. **select and apply** mathematical problem-solving techniques to discover **complex patterns** II. **describe patterns** as general rules consistent with **findings** III. **verify** the validity of these general rules.	The student is able to: ○ thoroughly and accurately plan on paper, using explanations and diagrams, the structure of the spreadsheet for task 2
7 – 8	The student is able to: I. **select** and **apply** mathematical problem-solving techniques to discover **complex patterns** II. **describe patterns** as general rules consistent with **correct findings** III. **prove, or verify and justify**, these general rules.	The student is able to: ○ explain all unique equations used in the first two rows of the Excel sheet for task 2 ○ use Excel to accept or reject the value of θ found in task 1 ○ use Excel to find an even more accurate value of θ to three decimal places