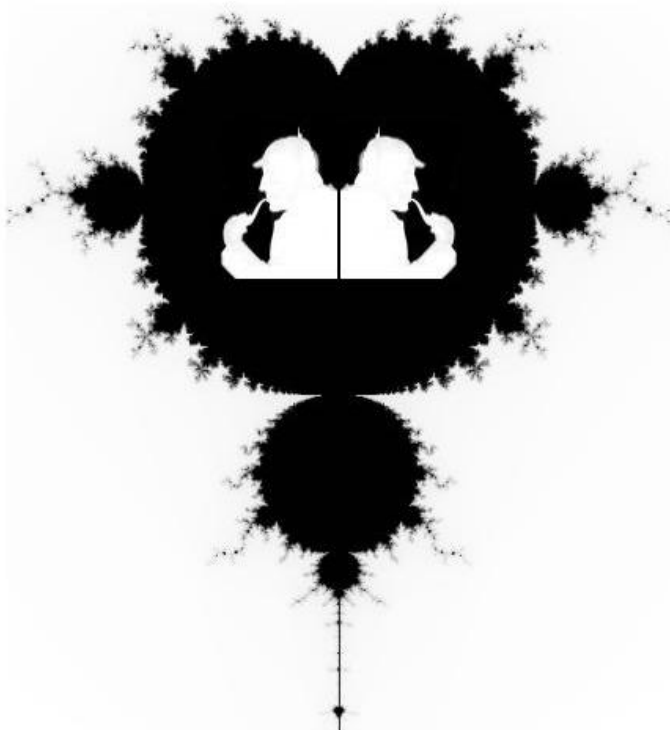


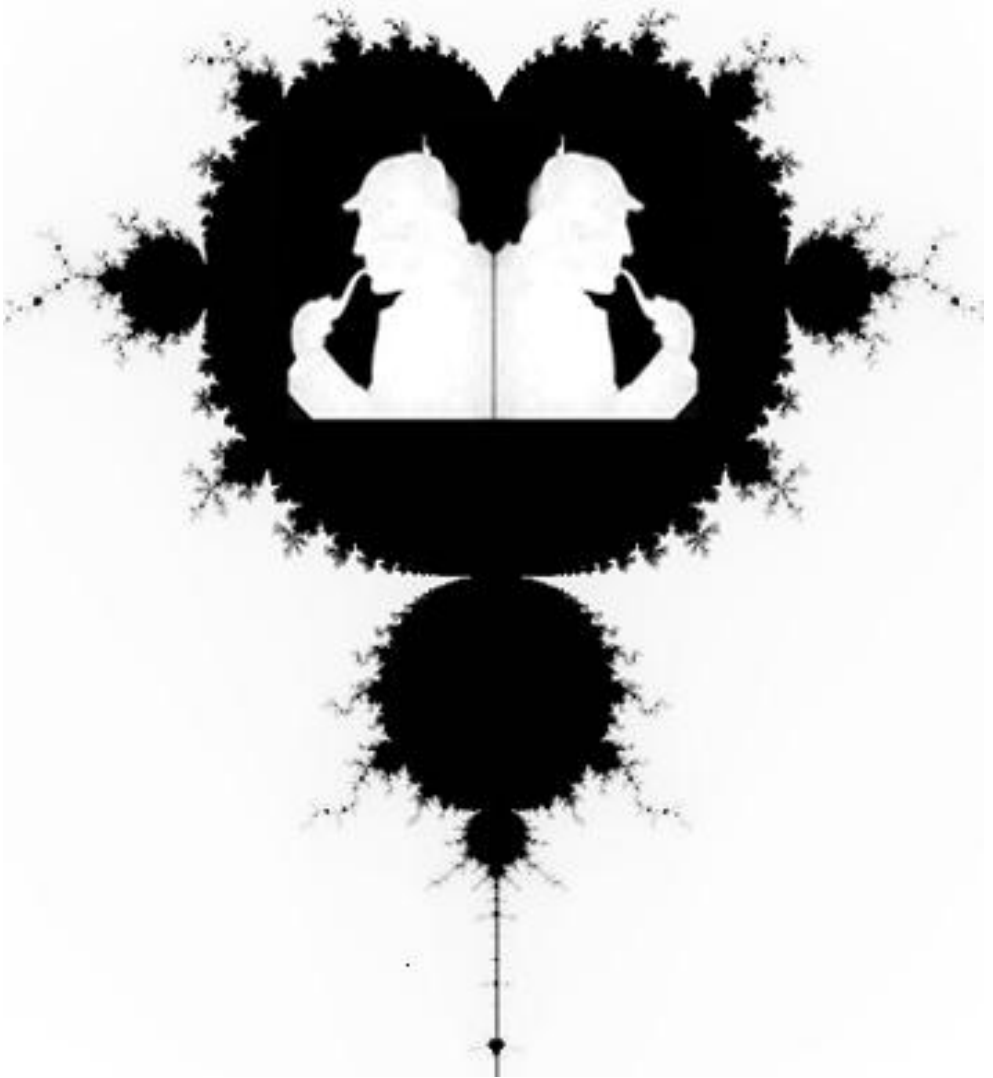
=EQUALS=

A CLUB OF INVESTIGATION AND DISCOVERY

Level 1

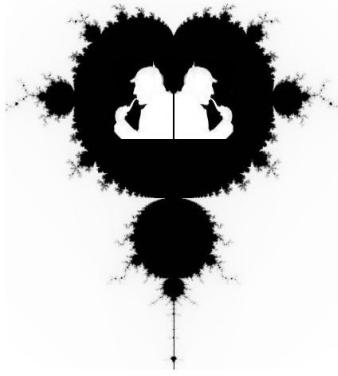
AN INTRODUCTION





ABOUT THE LOGO

The Mandelbrot Set, super-imposed with the image of Sherlock Holmes, suggests the marvel of the investigative process in seeking to understand nature.



=EQUALS=

A Club of Investigation and Discovery

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Center for
***auto* SOCRATIC EXCELLENCE**



LEVEL 1

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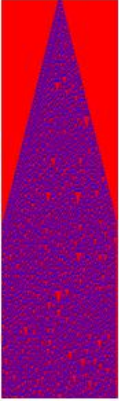
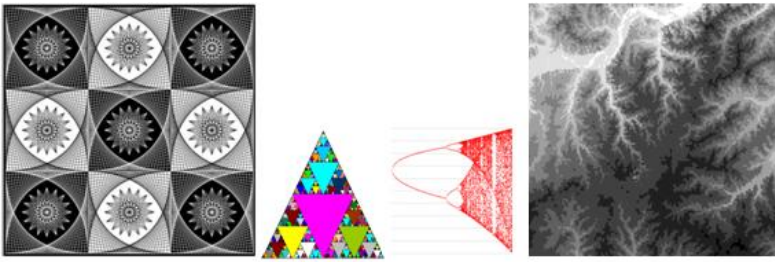
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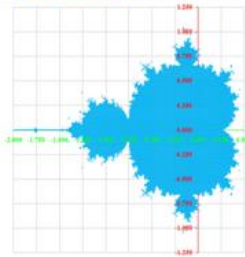
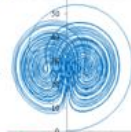
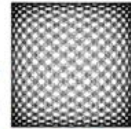
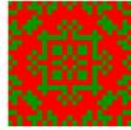
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=EQUALS= is a math, science, programming, and critical thinking club for students, parents, and teachers. The club is for persons of all ages and abilities, and is for those who not only enjoy math/science, but those who don't as well!

The goal of =EQUALS= is to look at fractals, simulation, statistics, chaos and complexity, engineering, math, astronomy, etc., from a new perspective - and actually do the work.

See the site for meeting information, contests, and a year-end "Mandelbrot Celebration!"



The Joy is in the Doing!



=EQUALS= is really about YOU doing SOMETHING! And in this regard, Shakespeare is the club spokesman!




“Things won are undone; joy's soul lies in the doing.”

Sample Pages / Sample Work

The Joy of Investigation and Discovery in Learning

Already, something doesn't seem right. After all, we're trying to model a Black Hole, which by definition, implies there is a winner in the astronomical tug-of-war: the Black Hole!



if...

Planets and stars should not be moving closer to one another.

and if...

Black holes are points so powerful everything, including light, gets sucked in.

then...

Planets and stars are moving closer to one another.

This contradiction I'll leave for later, as I want to get started trying to figure out how a black hole might work. Maybe my assumption "the planets are not moving" above is responsible for this contradiction. I'll retrace it a bit. As I said, I really want to simply get started. Note to self: as in the case with all contradictions, they must be resolved!

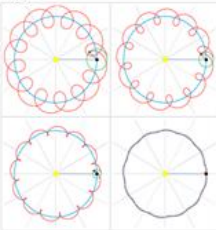
Retrograde Motion

RELATIVE DISTANCES

This model has helped me understand the nature of the full moon, and the difference between sidereal and synodic months. I don't want to lose focus here, as the original question dealt with Easter!

But another thought comes to mind, looking at the looping pattern of the moon's orbit.

Is this really what happens when we look in the sky? Does it look like the moon is going "backwards"? Is this always the case in our model? Let's change the radial distance of the moon's orbit and see what happens:



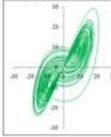
The Pysanky Revolution

UKRAINIAN EASTER EGGS IN A SPREADSHEET

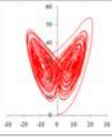


What can I do with this data? It's hard to create a i - j scatter plot in Excel, but I can plot the coordinates against one another. Let's see what this looks like:

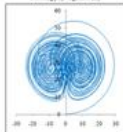
Plotting x vs. y against z



Plotting x vs. y against z



Plotting z vs. y against x



I want to use the Pythagorean Theorem to find c as I'll choose my point on the ellipse right at the y -axis, $(0, b)$.

The two foci are symmetric about the y -axis.

$$d_1 = d_2$$

Combining these two facts, I can derive the following:

$$d_1 = d_2 = 2a \quad d_1 = d_2$$

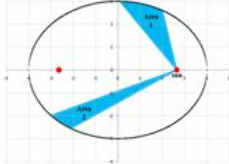
$$d_1 + d_2 = 2a + 2a$$

$$2d_1 = 2a + 2a$$

$$d_1 = a$$

And now that I have my triangle in terms of a and b , I can solve for c using the Pythagorean Theorem.


As Laves 1 and 2 look like something I can do something with in Excel, let's start there. Here's an example of these two laws:




I've got an ellipse, with the sun at one of the foci. The planet is revolving around the sun. When it's close to the sun, in a given period of time, it carves out a certain area. Let's call this "Area 1". In that same period of time *elsewhere* about the ellipse, it carves out the same area. Let's call this "Area 2".

Kepler's Second Law, therefore, says in the *same amount of time*, "Area 1" = "Area 2".

That's the idea. But to get started, I need an ellipse, and all I have is a blank spreadsheet!




Now looking at $\frac{1}{4}$ of the orbit of 27.3 days, the moon has is positioned at 270° . Straight down. Perfect!

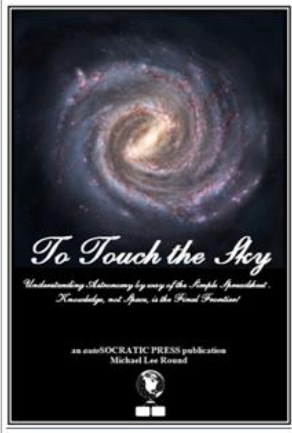
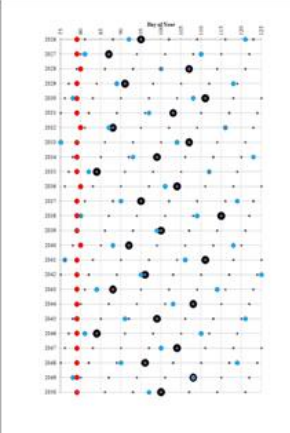


And finally, after 27.3 days, I see the moon back at the starting point: 360° . It's arrived back at the starting point.

And now I see the issue clearly, the difference between a sidereal month and a synodic month. I'm short of the full moon!



And by adding an additional 2.2 days, the moon is now aligned with the straight line between the sun and the earth = a full moon!



Some Goals / Advantages

The Joy of Investigation and Discovery in Learning

MULTIPLE ENTRY POINTS	SMALL LEARNING CURVE	SOFTWARE AVAILABILITY
There's an infinite number of things to study. Pick something that looks interesting and get going!	Most software has a steep learning curve. Excel really does not.	Most people have Excel on their computers.

QUICK VALIDATION	SELF-PACED	PROLONGED ANALYSIS
You know immediately if you've done something right - or wrong. Fix it and move on!	As there are 1,000 ways to skin a cat, and so too there are 1,000 ways to solve every problem.	You reach a point of success - or failure - and want to rest. Fine. Save your work. Recall the file. Improve the process.

PROCESS BREAKDOWN	RIGHT AND WRONG	MANY WAYS TO START
The spreadsheet format allows you to breakdown calculations and processes.	To get started doesn't mean it has to be exactly right - but it must be something to get you started!	Often, I see something neat and just want to understand it. Fine. Replicate it. Copy it. The key thing is to get started!

THE REAL WORLD	THE "NEW" MATH	PROBLEM SOLVING
Pascal's Principle. Astronomy. Apportionment. House Payments. Archimedes. The applications are right in front of us - and accessible to all!	Chaos Theory. Fractals. Simulation. Iteration. A "New Kind of Science". Strange Attractors. The "new math" is also right in front of us - and accessible to all!	Most math is within reach of most students. It's how to organize thoughts and data - to truly problem-solve - that is the result of doing the work!

A NEW LOOK AT MATH	INTERDISCIPLINARILY ...	A CAPABLE MIND
Simple logical thinking processes to understand not only math, but the world around us.	And effortlessly integrating this into the world around us - truly in an interdisciplinary format -	With the end-game not only authentic explorations into reality, but the realization <i>we can do it!</i>

Several Methods I Use in Excel ...

cell-formatting	scatter plots	line draw
pivot tables	simulation	animation
programming	formulas	data organization

The Certification Program

So what is the Certification Program?

So what is the Certification Program? The 5-Level “course” is intended to provide direction on specific projects – *something concrete you can do on your own* – leading to *you* working on *your own* projects and *your own* interests!

What is Involved?

Let’s answer this question by looking at this “Level 1” booklet.

In this booklet are 5 projects. As this is the “Level 1” booklet, each project is very explicitly laid out, and assumes the reader has little knowledge of the spreadsheet. In later Levels, such detail is not needed and, in fact, is more a burden than a help.

The steps are spelled out, in depth, not only in this booklet but the spreadsheets themselves.

To begin each project, there is a brief “intuitive introduction” to give you an idea of what’s trying to be accomplished. *What’s the question? What’s the issue?*

Once this “intuitive introduction” is complete, the steps are laid out on how to complete the project. That’s 90% of the process.

All the Rest

And the rest? For each project, now that it’s laid out, you can play with it a bit. In Project 1, for example, we randomly walk one step North, South, East, or West. What if we change this to walk a random distance between 0 and 2 steps? And instead of walking vertically or horizontally, we can walk *any* direction? These are (sometimes) simple extensions of the projects, but often lead to very interesting – and unexpected – results!

The Certification Program

THE CHECKLIST

At the end of this booklet is a checklist of things to accomplish. Completion of this list means “Level 1” has been passed. It’s an honor code, but there is a caveat – a warning: Levels 2 – 5 build on skills learned here. The simple macro structures learned here, for example, are used extensively later. *Get used to them here!* Get used to playing around in the spreadsheet! That’s really the goal of “Level 1”. HAVE FUN AND GET YOUR FEET WET!

And remember the injunction of Shakespeare:

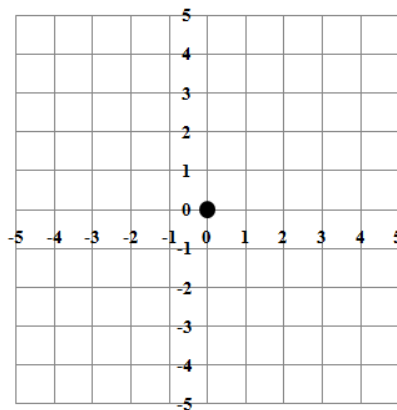
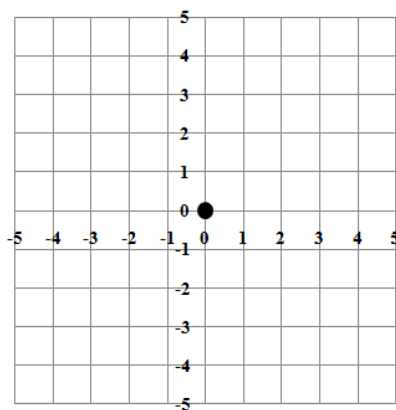
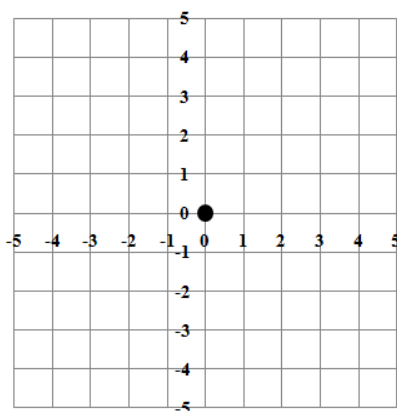
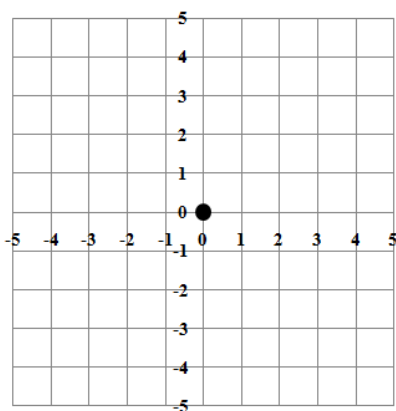
“Joy's soul lies in the doing.”

THE RANDOM WALK

INTRODUCTION

Suppose we started at a certain point, and then walked, randomly, up or down, left or right. Then we kept taking random steps. Where would we end up? Let's see.

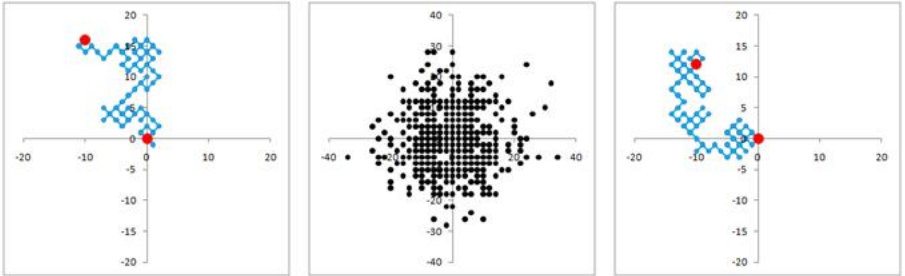
Let's try this with just 10 steps. Remember, with each step, you're saying (silently) to yourself (randomly): "RIGHT – LEFT – UP – DOWN" and then plotting that new step. Do this below, four different times, in each grid taking 10 random steps.



Now, let's go about automating the process!

THE RANDOM WALK

LET'S BEGIN



STEP 1: *Calculate the First Move*

Suppose we start at Position (0, 0). We want to move, randomly, right or left, and up or down. *How do we do this?* In columns B and C, we will use the “Random” function (that is, a random number between 0 and 1) to move. The formula is:

=if(rand()>0.5,1,-1) Type this in cells b5 and c5.

This is read as follows: *if* our random number between 0 and 1 is greater than 0.5, *then* put ‘1’ in the cell, *ELSE* put a ‘-1’ in the cell.

STEP 2: *Calculate Our New Position*

Columns D & E plot our *current* position after each move. What *is* our current position after any move?

Current Position = Where we were + “Next Move”.

The formula, then, for cell d5 is:

=d4+b5

Copy this formula to cell e5.

NOTE

*If, at any time, you're not sure if it's calculating properly,
hit the F9 KEY to recalculate!*

STEP 3: Calculate our Move and Position for all 100 Moves

That's just one move. Now, copy cells b5:e5, and then paste it for all 100 moves.

STEP 4: Graph the Data

We've got a table of numbers, but it's hard to tell how you're moving with a table. Therefore, let's graph the data. Select all "current position" coordinates (cells d4:e104) and, using the pull-down menus, Select "Insert", and then "Scatter Plot".

NOTE

After you've created the graph, the graph is at the bottom of all the data points. I don't like that. I always highlight the graph, right click "cut", and then come back up here, and right click "paste".

NOTE 2

This is now a "Random Walk". Every time you hit the "F9" key, (recalculate), the random walk changes. There are a couple things you'll notice, and may want to change:

STEP 5: Seeing the Route Better

These are just points, and you want a *route*. Select the data series in the graph, right click, and select "Format Data Series". Under "line color", select "solid line", and choose a color.

STEP 6: *Fixing the Axis to See the Route Better*

The routes bounce all over the place. *Why?* The axis values are changing. Let's make them fixed.

Select any number along the x -axis, right click, and select "Format Axis".

Under "Format Options", change the "Minimum and Maximum" to "Fixed", and set these to -20 (minimum) and 20 (maximum).

Repeat the process for the y -axis.

STEP 7: *Reshape the Rectangular-Looking Graph*

Our coordinates suggest a square graph, but it doesn't look square. Reshape the graph to be square.

OTHER IDEAS

What else? Here are some ideas to play around with:

IDEA 1: *Add the Start and End Point*

This is the route of 100 random moves. We always started at $(0,0)$, but it's hard to tell where we ended. Add a data series to show only these two points. An idea: because we're adding a new data series, at the top of the spreadsheet, create the template for the new series, something like this:

	x	y
start:	0	0
finish:		

And the “finish” coordinates? We merely make a cell-reference to the last move, so every time we run the program, the “start” and “finish” are updated!

And now what? Now we need to “add a data series”.

Adding a Data Series

Click on the graph, and, from the pull-down menus, select “Design”, click on “Select Data”, and then “Add”.

The options show “Series x-values” and “Series y-values”, along with a “Select Range” button. For each option, highlight the appropriate range of values in the spreadsheet.

IDEA 2: Write a Program to Show 100 Random Routes

We’re hitting “F9” to recalculate. Write a short macro to simulate 100 random routes.

Remember, the key to writing most macros is figuring out what you’re doing — manually. Once you know that, turn on the macro-record feature and do that! To do this, under the pull-down menu “Developer”, select “Record Macro”, and then do your keystrokes.

Once done, turn *off* the Macro-Record feature with “Developer”, “Stop Recording”.

Now, go back in and see what the macro recorded, clean up the macro to do what you actually want it to do, and then run it! A sample macro for this project might look like:

```
Sub Macro4()  
For LOOPING = 1 To 100  
    Calculate  
Next LOOPING  
End Sub
```

IDEA 3: *Randomize the Moves Even More*

We've restricted our movements to steps of 1 unit long. Change this to be a random distance between 0 and 2.

IDEA 4: *Graph the Ending Points for Many Routes*

You'd like to capture the results of the 100 random routes. Where did you *finish*? Write a short macro to capture these 100 ending points, and graph the results. We will cover this in "Level 2", but give some thought to it!

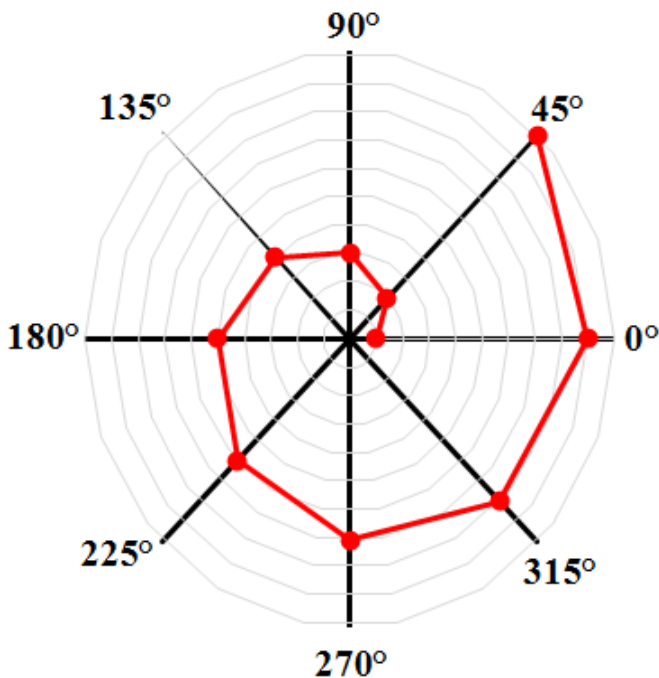
THE PRIME SPIRAL

INTRODUCTION

Graph prime numbers below 10,000

To get an idea what this means – to graph prime numbers – let’s look at just 10 numbers – and not even primes. Just 1, 2, 3, ... 10. But in graphing something, we need a *second* coordinate, *don’t we?* Instead of a coordinate, let’s move a certain number of degrees around the circle.

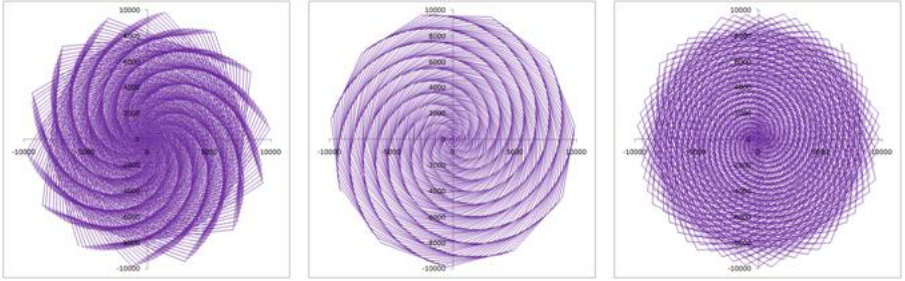
For example, let’s start at 0° – the horizontal axis – and go over one unit (circle) and make a point. Now advance 45° and make a point at two units. Move another 45° (you’re now at 90°) and mark off three units. Continue until you’ve completed all 10 points. Once done, connect the points.



You get the idea. But here we’ve assumed a “shift” of 45° . What happens when this changes? What happens if we plotted just primes? Let’s get started!

THE PRIME SPIRAL

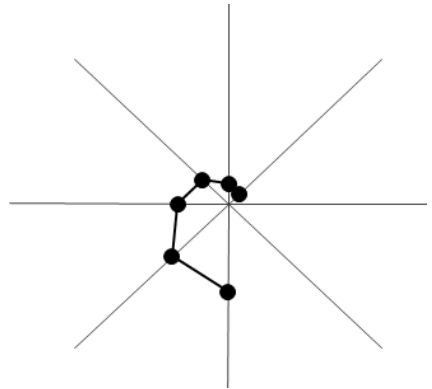
LET'S BEGIN



STEP 1: *We've Got the Number: We Need the Angle*

We're trying to plot the prime numbers by changing the angle. For *each* number, then, the angle must change. Let's say this change is 45 degrees, in cell b1.

Prime	Angle
2	45
3	90
5	135
7	180
11	225
13	270



Starting with angle 0, each angle must be a multiple of our "degree change" number. In cell b4, then, the formula is:
$$=b3+b1$$

If you copy that formula down, you'll see the values don't look like they should (0, 45, 90). *Why?* We no longer are referencing Cell b1. We need to "anchor" it.

In cell b4, then, the formula should be:
$$=b3+\$b\$1$$

Copy this formula to cells b4:b1231.

Now, you see each cell formula still recognizes “\$b\$1”.

STEP 2: *But a Problem Arises*

We're use to working in degrees, but Excel *does not* recognize degrees – only radians! See the end of this document for more information on how to do this. Additionally, we'll see why I've not reduced the below to the familiar formula.

In column C, change degrees to radians with the formula:

$$=b3*2*3.14159/360$$

Copy this formula to cells c4:c1231.

STEP 3: *Finding – and Graphing – the Coordinates*

Right now, we've got a distance and an angle for each point. These are “Polar Coordinates”.

We want “Cartesian Coordinates”, i.e., x and y coordinates. Therefore:

in column D, the formula is: $=a3*\cos(c3)$

in column E, the formula is: $=a3*\sin(c3)$

Copy these formulas to cells d4:e1231.

OTHER IDEAS

What else? Here are some ideas to play around with:

IDEA 1: *We're Entering the Degrees – and Hitting F9 – Manually.*

Write a Macro to do it Automatically

We're done! But are we? This is based on a single "degree change" figure. Write a short macro to change this figure from 0 to 360, increasing by 1 degree.

A hint: since cell B1 is the important cell here – that is, it's the cell where if we change its value, the graph changes – let's have our macro send a value to that cell. For example:

```
Sub Macro4()  
For LOOPING = 0 To 360  
    Range("B1").value = LOOPING  
    Calculate  
Next LOOPING  
End Sub
```

IDEA 2: *The Prime Numbers*

Getting back to prime numbers, where did the prime numbers come from? I've put the prime numbers here. Write a program to calculate them yourself! We will cover this in "Level 2".

FUN DESIGNS

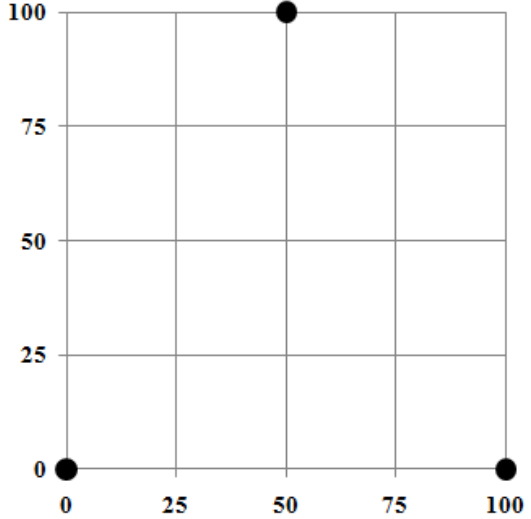
INTRODUCTION

To embed a triangle within a triangle, continually using the midpoints of each segment.

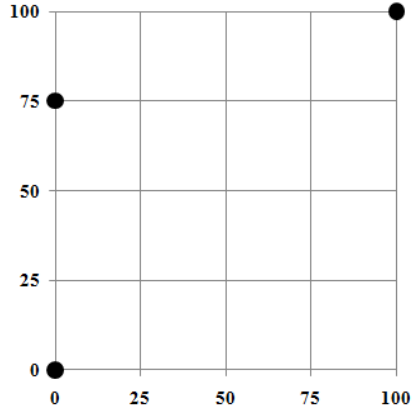
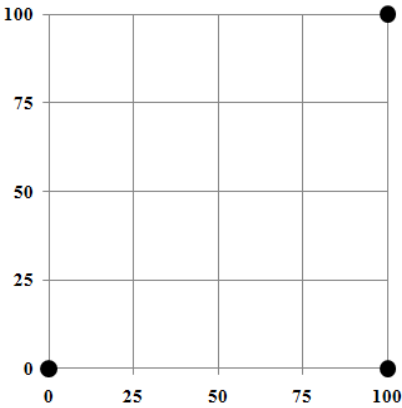
To get the idea, let's start with any three points, and connect these points.

Next, find the midpoints of *these* line segments and connect these points.

And continue!

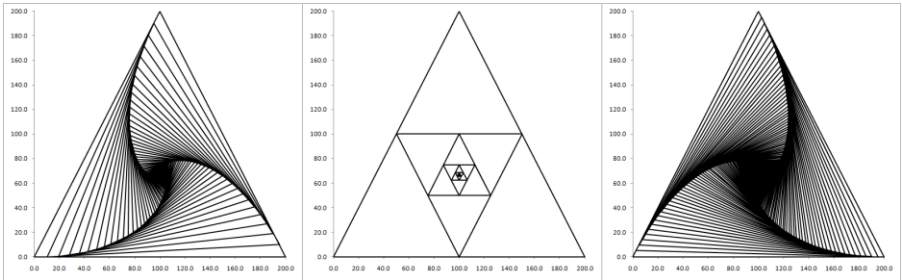


Let's try a couple more:



FUN DESIGNS

LET'S BEGIN



STEP 1: *The Start of a Graph*

Create a scatter plot of the three points. You know how to do this. Already seeing how to format the graph, reset the x and y -axis ranges to:

minimum = 0, maximum = 200.

This will be a line graph, so reformat the data series to include a line. (Remember: to reformat the graph, click anywhere on the data series in the graph, right click, and select “format data series” to show all the options).

STEP 2: *Finishing the Triangle*

You see, with these three points, we don't yet have a triangle. To *complete* the triangle, we need our 4th point to be the same as the first point.

In cell b7, then, reference the first point with the formula

=b4

and copy this to cell c7.

Hitting the recalculate key (F9), you still don't see a complete triangle, despite adding the 4th point. Why not? The data series we're graphing was only for the first three sets of points we highlighted.

Let's change this. Click on the series in the graph. You see in the "Formula Bar" above the graph the cell references b4:b6 and c4:c6. Change these to b4:b7 and c4:c7.

Hitting the "enter" key to exit the formula bar, you should now see the complete triangle.

And since we're about to add many more points, let's edit the series to show not just the first four points, but about four *hundred*. Change the series to b4:b400 and c4:c400.

STEP 3: *Constructing the Next Triangle*

For our next triangle, we need to find the midpoints of each of the corresponding line segments. What is the formula for such a midpoint?

The formula for the midpoint of two points A and B is $(A + B)/2$

In cell b8, then, the formula is

$$=(b4+b5)/2$$

We want to copy this to cells b8:c10.

As before, we need to close out this new triangle, by bringing the line segment back to the initial point.

In cell b11, then, reference the first point with the formula

$$=b8$$

and copy this to cell c8.

STEP 4: *Many Triangles Quickly*

You may be thinking: this is going to take a long time, entering all these formulas. You may also have noticed these last four rows all reference the cells above them.

Therefore, if we copy these four rows (cells b8:c11) into the next four open rows (select b12:c15), we'll have our next triangle!

AND SO ON!

OTHER IDEAS

What else? Here are some ideas to play around with:

IDEA 1: *Moving Other Distances Along the Triangle*

Are we done? Maybe. This triangle figure only moves $\frac{1}{2}$ the way. What if we move $\frac{1}{4}$ of the way? 90% of the way?

As we did in the Prime Spiral figure, let's create a reference number in cell C1. This will be a number between 0 and 1. (Right now, for example, by using the midpoint, we're really assuming $C1 = 0.50$).

What do we need to change?

Everywhere we previously said $(A+B)/2$, we need to change this formula. See the end of this document for further reference.

A general formula for the new point is:

$$(\text{Distance between Two Points}) (\% \text{ Move}) + \text{Start Point}$$

or

$$(\text{End Point} - \text{Start Point}) \times (\% \text{ Move}) + \text{Start Point}$$

or

$$=(b5-b4)*\%c\$1+b4$$

Copy this to cells b8:c10, and redo the process, as we did above.

IDEA 2: *Create an Animation to Show these new Distances*

Are we done? Maybe. Create a short macro to go from 0 to 1, showing all these images.

The macro could step from 0 to 100 and then divide each number by 100. Or the macro could step from 0 to 1, but then you must tell it to “Step 0.01”. These two sets of commands are identical:

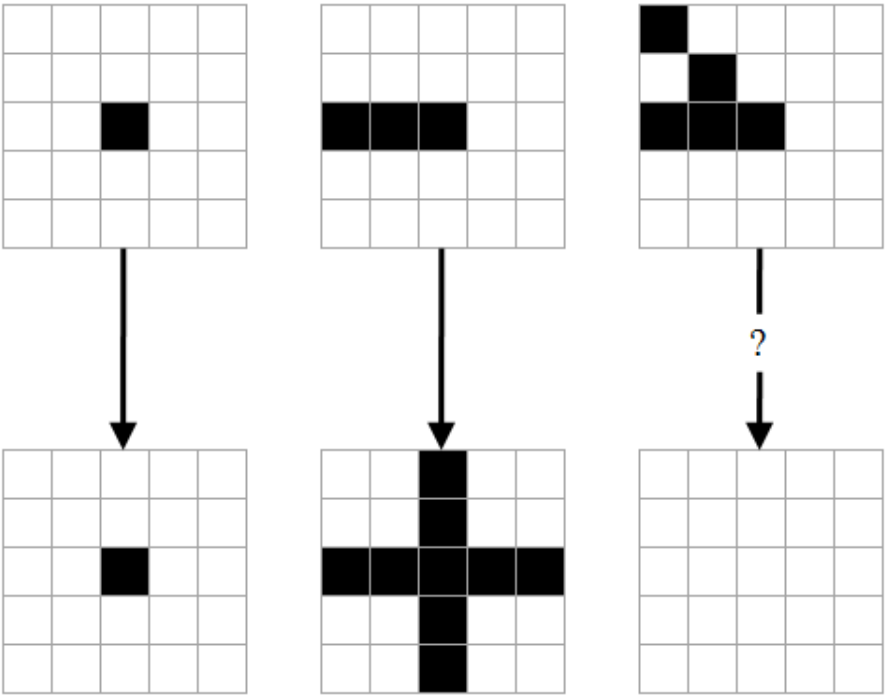
<pre>Sub Macro5() For LOOPING = 0 To 100 Range("C1").value=Looping/100 Calculate Next LOOPING End Sub</pre>	<pre>Sub Macro5() For LOOPING = 0 to 1 step 0.01 Range("C1").value=Looping Calculate Next LOOPING End Sub</pre>
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SYMMETRIC DESIGNS

INTRODUCTION

To create random and symmetric designs.

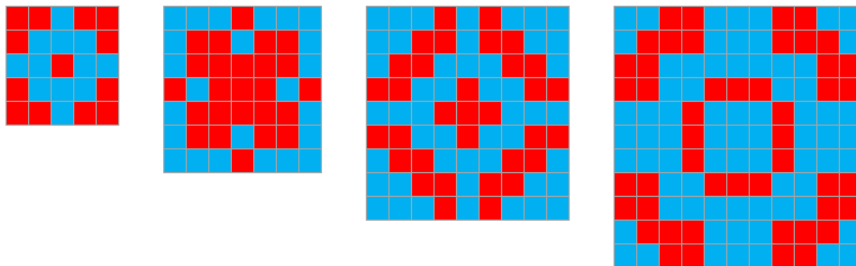
We're going to make a neat design – a *symmetric design* – symmetric about a center square. Look at the grid on the far left, for example. There's only a colored square in the middle, so there's no more work to do. With the middle example, it's easy to see how to extend this symmetrically. How would you complete the symmetry for the grid on the right?



SYMMETRIC DESIGNS

LET'S BEGIN

To create random and symmetric designs.



STEP 1: *Create the Random Part of the Grid*

Suppose we start with a 5 x 5 grid. What does it take to create this symmetry? Let's see:

STARTING GRID	Because of symmetry, I can fill these three cells by referencing the appropriate cells.	Because of symmetry, I can fill these six cells by referencing the appropriate cells.	Because of symmetry, I can fill these ten cells by referencing the appropriate cells.																																																																																																				
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As you can see, all cell entries are based on only the six numbers in STARTING GRID (far left). *We're now going to be working in the "Working Grid"*

Let's randomize what we put in these six cells with our familiar

$$=if(rand()>0.5,1,0)$$

formula. This returns, with equal probability, 0 or 1.

STEP 2: *Finishing the Grid*

Use Cell references to make the entire Working Grid symmetric. That is, because our grid is symmetric, each empty cell is now equal to one of these six cells. We merely have to say =(whatever cell) for each of these empty cells.

Follow the outline as shown on the display. For example, because of symmetry, cell M18 is the same as L19. Therefore, in cell m18 we put the formula:

=L19

But these are all *numbers*, and we want *colors*. We're going to conditionally format our cells to show everything as either black or white.

What we want is to make both the font – and the background – black – IF the cell value is 1. On the other hand, if the cell value is 0, we want both the font and background to be white.

STEP 3: *Creating Black Cells*

Highlight the entire “Working Grid”, and Under the Home menu option is the pull-down menu “Conditional Formatting”.

We want to “Highlight Cells Rules”, and select “equal to” *I*

with: (custom format):

make the font color BLACK

fill the cells with BLACK

In doing this, you can still see the zeros. Let's make these zeros WHITE, by doing the same thing as above.

STEP 4: *Creating White Cells*

We want to “Highlight Cells Rules”, and select “equal to” 0
with: (custom format):
make the font color WHITE
fill the cells with WHITE

OTHER IDEAS

What else? Here are some ideas to play around with:

IDEA 1: *Making Our Grid Bigger*

Are we done? Of course not. How many different symmetric designs are there here? What happens if we add a column to both sides (and a row to the top and bottom)?

We now have 10 main cell entries.

IDEA 2: *Creating a Binary to Decimal Name for our Graphic*

If we combine these 10 cell entries of 1s and 0s, we have a 10-digit binary number. How could we change the nomenclature to make this a decimal number? We will cover this in “Level 2”.

THE SUPER BOWL

The History and Geography of the Super Bowl

Whether or not you're a football fan, let's take a look at the history of the Super Bowl.

The first Super Bowl, Super Bowl 1, took place January 15, 1967 in Los Angeles, California. The most recent Super Bowl, Super Bowl 45, took place February 6, 2011, in Arlington, Texas.

What about the *other* Super Bowls? *Where have they been played?* And how can we display all this data in a graph?

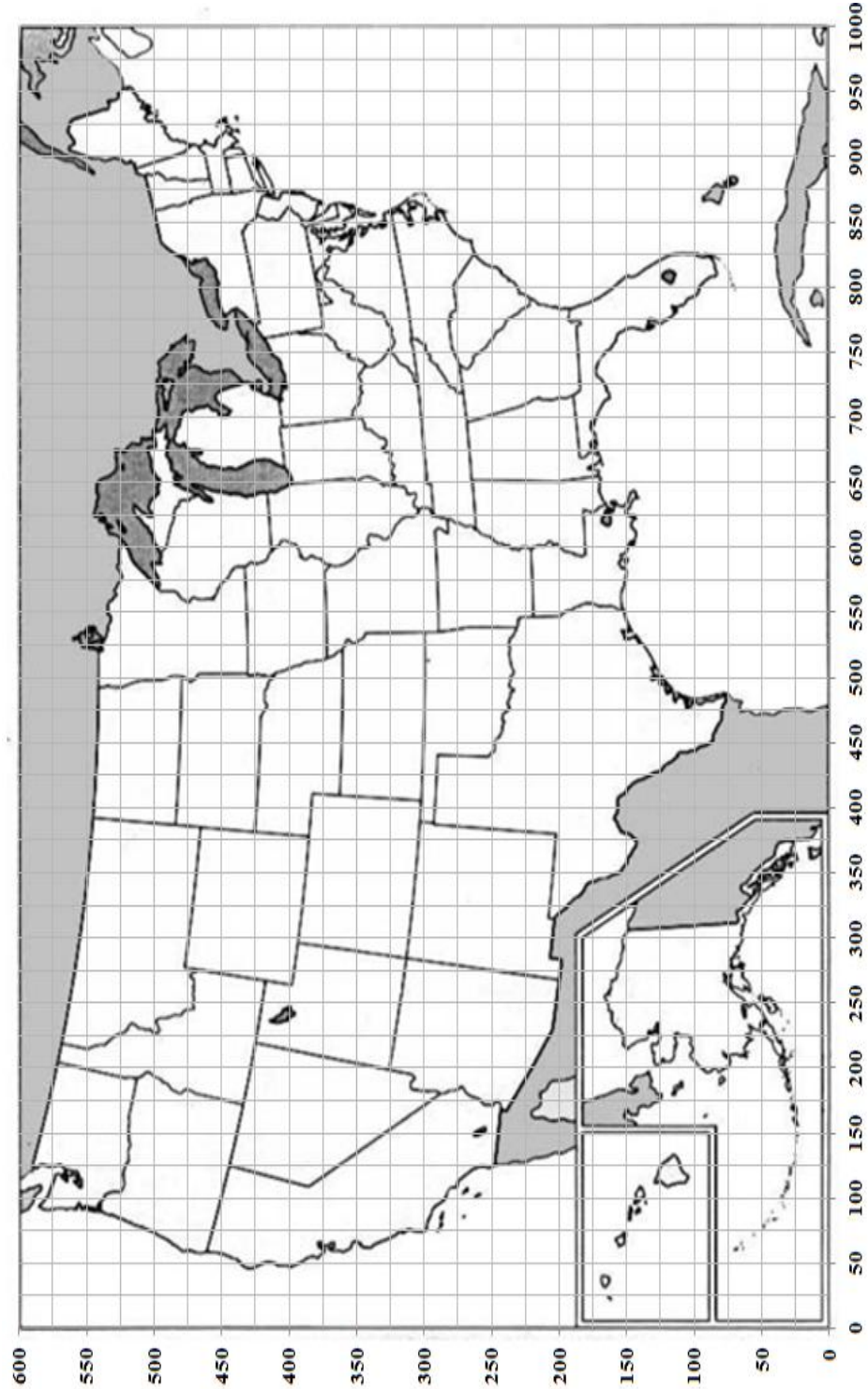
Of course, I'm sure we could find a map that's plotted all of these. If not, we could easily find the longitude and latitude. But this could be a lot of work, and is probably more precise than what we're looking for, merely graphing data in our spreadsheet.

What alternative is there?

Look at the following map. Laid out on the map is a coordinate system. On the following two pages are the locations of all Super Bowls.

YOUR TASK

Quickly find each city on a map, plot the point on the graph, and then record the x and y coordinates in the accompanying table.



The History of the Super Bowl

#	Date	Winner	Score	Loser	City	x-coord	y-coord
1	01/15/67	Green Bay	35-10	Kansas City	Los Angeles, CA		
2	01/14/68	Green Bay	33-14	Oakland	Miami, FL		
3	01/12/69	New York	16-7	Baltimore	Miami, FL		
4	01/11/70	Kansas City	23-7	Minnesota	New Orleans, LA		
5	01/17/71	Baltimore	16-13	Dallas	Miami, FL		
6	01/16/72	Dallas	24-3	Miami	New Orleans, LA		
7	01/14/73	Miami	14-7	Washington	Los Angeles, CA		
8	01/13/74	Miami	24-7	Minnesota	Houston, TX		
9	01/12/75	Pittsburgh	16-6	Minnesota	New Orleans, LA		
10	01/18/76	Pittsburgh	21-17	Dallas	Miami, FL		
11	01/09/77	Oakland	32-14	Minnesota	Pasadena, CA		
12	01/15/78	Dallas	27-10	Denver	New Orleans, LA		
13	01/21/79	Pittsburgh	35-31	Dallas	Miami, FL		
14	01/20/80	Pittsburgh	31-19	Los Angeles	Pasadena, CA		
15	01/25/81	Oakland	27-10	Philadelphia	New Orleans, LA		
16	01/24/82	San Francisco	26-21	Cincinnati	Pontiac, MI		
17	01/30/83	Washington	27-17	Miami	Pasadena, CA		
18	01/22/84	Los Angeles	38-9	Washington	Tampa, FL		
19	01/20/85	San Francisco	38-16	Miami	Stanford, CA		
20	01/26/86	Chicago	46-10	New England	New Orleans, LA		
21	01/25/87	New York	39-20	Denver	Pasadena, CA		
22	01/31/88	Washington	42-10	Denver	San Diego, CA		
23	01/22/89	San Francisco	20-16	Cincinnati	Miami, FL		
24	01/28/90	San Francisco	55-10	Denver	New Orleans, LA		

The History of the Super Bowl

#	Date	Winner	Score	Loser	City	x-coord	y-coord
25	01/27/91	New York	20-19	Buffalo	Tampa, FL		
26	01/26/92	Washington	37-24	Buffalo	Minneapolis, MN		
27	01/31/93	Dallas	52-17	Buffalo	Pasadena, CA		
28	01/30/94	Dallas	30-13	Buffalo	Atlanta, GA		
29	01/29/95	San Francisco	49-26	San Diego	Miami, FL		
30	01/28/96	Dallas	27-17	Pittsburgh	Tempe, AZ		
31	01/26/97	Green Bay	35-21	New England	New Orleans, LA		
32	01/25/98	Denver	31-24	Green Bay	San Diego, CA		
33	01/31/99	Denver	34-19	Atlanta	Miami, FL		
34	01/30/00	St. Louis	23-16	Tennessee	Atlanta, GA		
35	01/28/01	Baltimore	34-7	New York	Tampa, FL		
36	02/03/02	New England	20-17	St. Louis	New Orleans, LA		
37	01/26/03	Tampa Bay B	48-21	Oakland	San Diego, CA		
38	02/01/04	New England	32-29	Carolina	Houston, TX		
39	02/06/05	New England	24-21	Philadelphia	Jacksonville, FL		
40	02/05/06	Pittsburgh	21-10	Seattle	Detroit, MI		
41	02/04/07	Indianapolis	29-17	Chicago	Miami, FL		
42	02/03/08	New York	17-14	New England	Glendale, AZ		
43	02/01/09	Pittsburgh	27-23	Arizona	Tampa, FL		
44	02/07/10	New Orleans	31-17	Indianapolis	Miami, FL		
45	02/06/11	Green Bay	31-25	Pittsburgh	Arlington, TX		
46	02/05/12				Indianapolis, IN		
47	02/03/13				New Orleans, LA		
48	02/01/14				East Rutherford, NJ		

THE SUPER BOWL

The History and Geography of the Super Bowl

Having collected all of this data, instead of having our points plotted on a piece of paper, let's plot them over the image of the map that is in the spreadsheet. *How do we do this?*

STEP 1: *Input All of the Data*

Obviously! In the table beside the map is a table with missing x and y coordinates. Update this table with the data you've just collected.

STEP 2: *Graph All of the Data*

Create a scatter plot from the table of coordinates. You know how to do this. Already seeing how to format the graph, reset the axes as follows:

x -axis range: minimum = 0, maximum = 1000;

y -axis range: minimum = 0, maximum = 600.

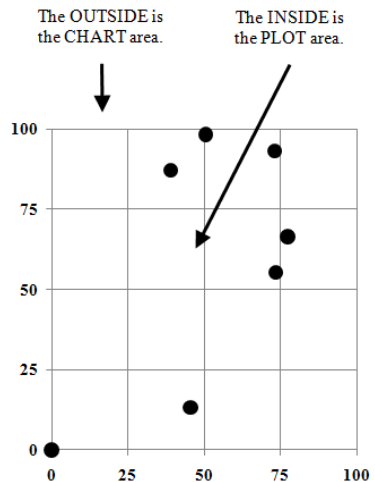
STEP 3: *See Both the Map and the Graph*

Right now, we've got a map underneath our graph, *but you can't see it!* The graph is "in the way"! We need to make the graph transparent.

To do this requires us to recognize there are really *two* parts to the graph: the *Chart Area* and the *Plot Area*.

Do the following steps for both the "Chart Area" and the "Plot Area":

1. Click on the area (Chart or Plot), right click, and then select "format" at the bottom;
2. Select "Fill", "Solid Fill", and then move the "Transparency bar" all the way to 100%.



THE PRIME SPIRAL

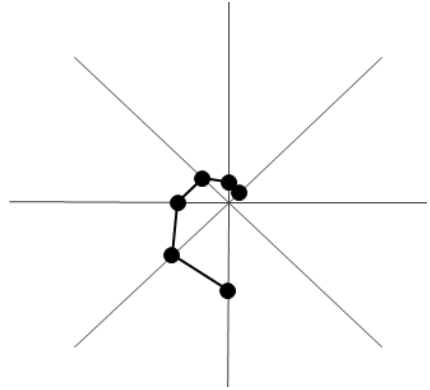
AND MOVING ABOUT THE GRID

Appendix A

I want to “move about” the grid by creating evenly-spaced angles, and then move up an imaginary line on that angle by the distance of the next prime number.

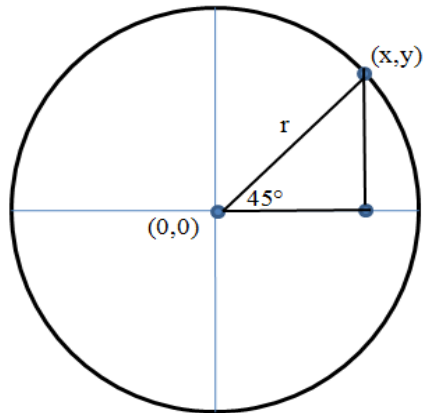
For example, if I evenly spaced out the angles by 45 degrees and started plotting the prime numbers, *what would happen?*

Prime	Angle
2	45
3	90
5	135
7	180
11	225
13	270



Here's a start:

There are really two ways I can visualize these points. One is by the distance and angle (r, α). The other is by moving relative to the x - and y -axis. These two methods of moving – these coordinate systems – are:



Coordinate Systems	
POLAR	CARTESIAN
(r, α)	(x, y)

But how do go from Polar Coordinates (which I know) to Cartesian Coordinates (which I don't)? How do I find (x, y) ? A bit of trigonometry helps in this regard, as I know the following basic relationships (using 45° as an example):

$$\sin(\theta) = \frac{\textit{opposite}}{\textit{hypotenuse}} \quad \cos(\theta) = \frac{\textit{adjacent}}{\textit{hypotenuse}} \quad \tan(\theta) = \frac{\textit{opposite}}{\textit{adjacent}}$$

It seems simple enough: substitute x , y , r , and 45° and I can arrive at sine and cosine relationships, enabling me to solve for x and y :

$$\begin{array}{ccc} \cos(45^\circ) = \frac{x}{r} & & \sin(45^\circ) = \frac{y}{r} \\ \downarrow & & \downarrow \\ x = r \cos(45^\circ) & & y = r \sin(45^\circ) \end{array}$$

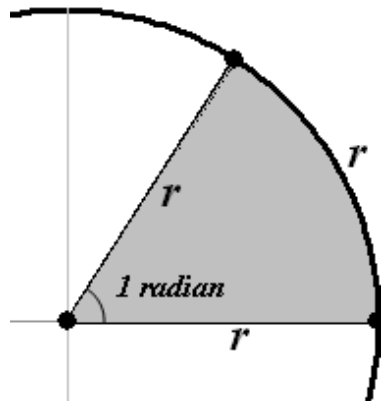
But Microsoft doesn't use degrees – it uses **radians**. *What are radians* – and how do I convert degrees *to* radians? Let's find out.

DEGREES TO RADIANS

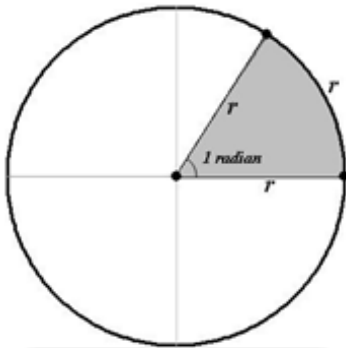
AND MOVING ABOUT THE GRID

Look at my semi-circle with radius r . I've actually got *three* distances labeled r here: two *are* the radius, and the other is the same distance, but this time measured as we move *around* the circle.

My question is: how many degrees have I “carved out” when I move the distance r around the circle? Answer: ***1 radian***.



“Radian” is a degree measure. It’s between 45° and 90° ... you can tell that just by looking. But *how* far exactly? Let’s see:



One radian takes me a distance r around the circle.

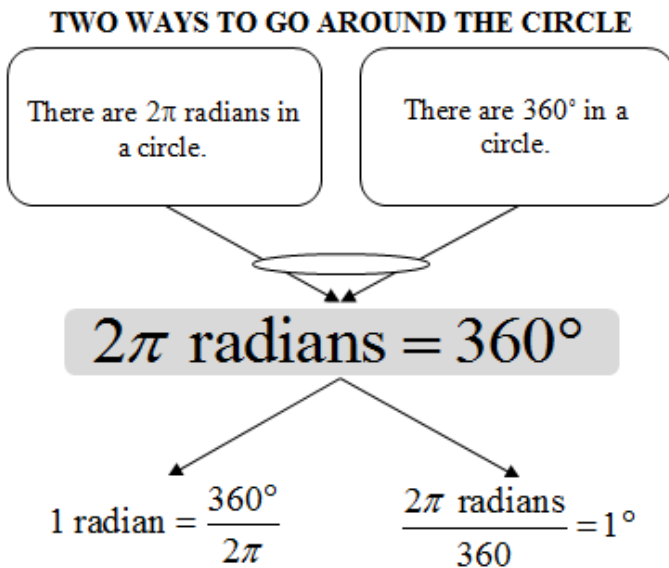
The circumference of a circle is $C = 2\pi r$.

There are 2π radians in a circle.

If I move 2π radians around the circle, then I’m back where I started: 360° . π radians and I’m only *halfway* around the circle: 180° .

CONVERTING BETWEEN RADIANs AND DEGREES A GENERAL METHOD

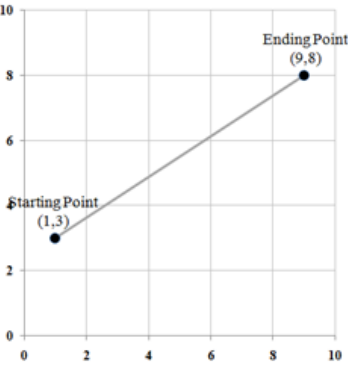
You really don't have to remember *any* formulas. Instead, think of this: *there are two ways of going all the way around the circle:*



MOVING A CERTAIN DISTANCE BETWEEN POINTS

Appendix B

Suppose I want to move a certain distance between two points. Let's say the starting point is (1, 3), the ending point (9, 8), and I want to go 75% ($3/4^{\text{th}}$) of the way. *What's my new point?*

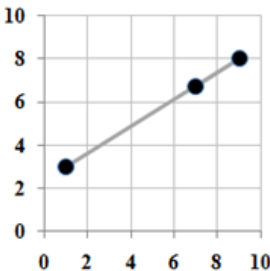


The x-distance between the two points is $(9 - 1) = 8$ and the y-distance between the two points is $(8 - 3) = 5$

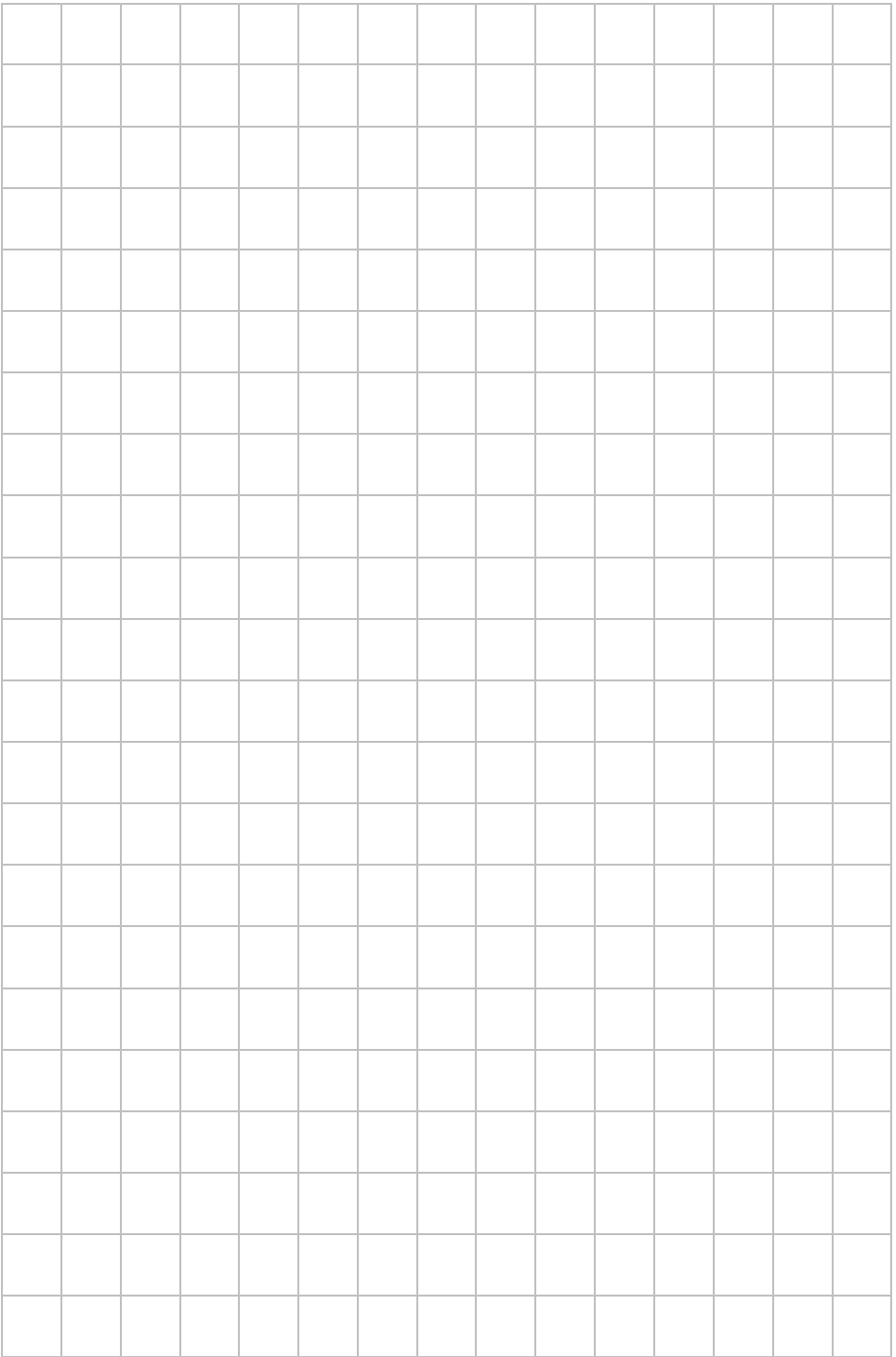
I want to move 75% of the way, starting at "Starting Point" and moving to "Ending Point".

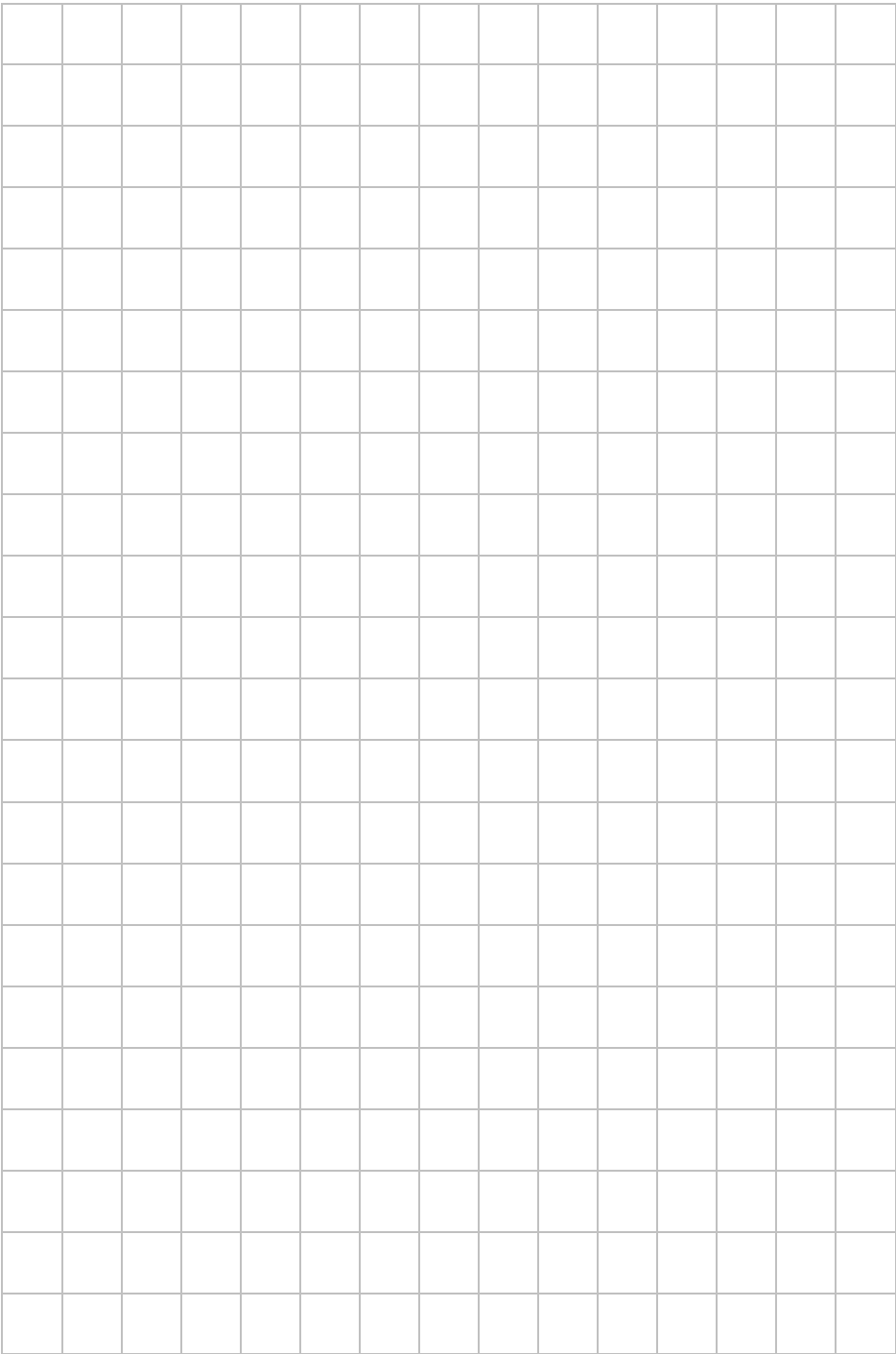
The x-distance moved is $(9 - 1)(0.75)$ and the y-distance moved is $(8 - 3)(0.75)$

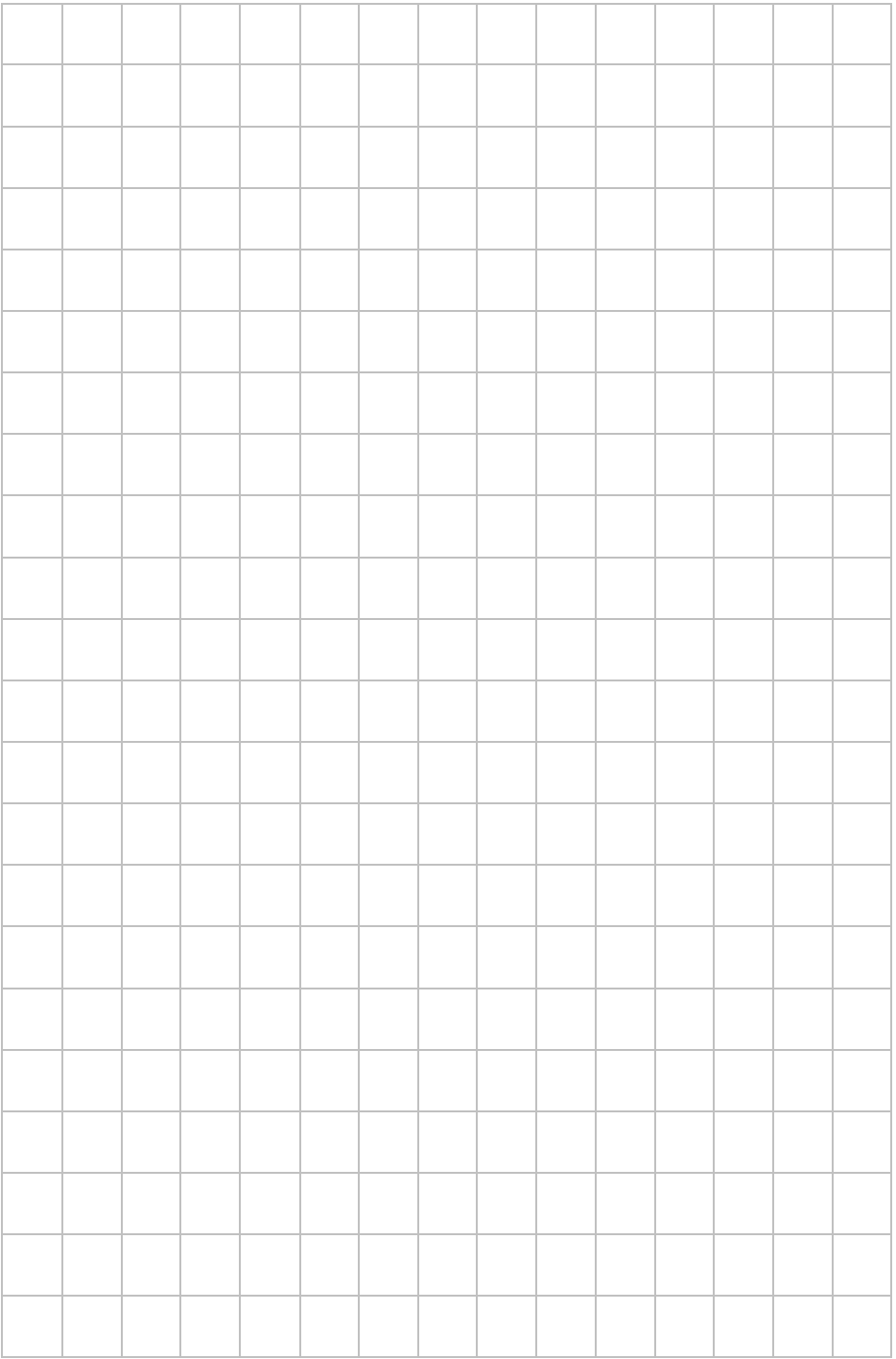
The "Starting Point" is (1, 3).



My new coordinates are:
 $x = 1 + (9 - 1)(0.75) = 7.00$
 $y = 3 + (8 - 3)(0.75) = 6.75$







Level 1 Checklist

RANDOM WALK

- _____ Complete Steps 1 – 7;
- _____ Idea #1 (add the endpoint as a new data series);
- _____ Idea #2 (write a program to simulate 100 random routes);
- _____ Idea #3 (change the route to a random step 0 – 2 steps long);
- _____ Start with a blank spreadsheet, and recreate Steps 1 – 7 from scratch. Use the current spreadsheet as a template, if you need help, but work to recreate everything. You'll find, though this might take a bit of time at first, you'll soon be able to do it in minutes!

THE PRIME SPIRAL

- _____ Complete Steps 1 – 3;
- _____ Idea #1 (write the macro to change degrees);
- _____ Start with a blank spreadsheet, and recreate Steps 1 – 3 from scratch. Use the current spreadsheet as a template, if you need help, but work to recreate everything.

FUN DESIGNS

- _____ Complete Steps 1 – 4;
- _____ Idea #1 (change the formulas to move a certain fraction);
- _____ Idea #2 (write a macro to animate the change);
- _____ Start with a blank spreadsheet, and recreate Steps 1 – 4 from scratch. Use the current spreadsheet as a template, if you need help, but work to recreate everything.

Level 1 Checklist

SYMMETRIC DESIGNS

- _____ Complete Steps 1 – 4;
- _____ Idea #1 (make the grid bigger);
- _____ Start with a blank spreadsheet, and recreate Steps 1 – 4 from scratch. Use the current spreadsheet as a template, if you need help, but work to recreate everything.

THE SUPER BOWL

- _____ Collect the coordinate data for all Super Bowls;
- _____ Complete Steps 1 – 3.

QUESTIONS

If you have a question, look to the FAQ site first. If it's not there, ask it! Help yourself – and help others!

www.rationalsys.com/equalsclub_discussion.html

