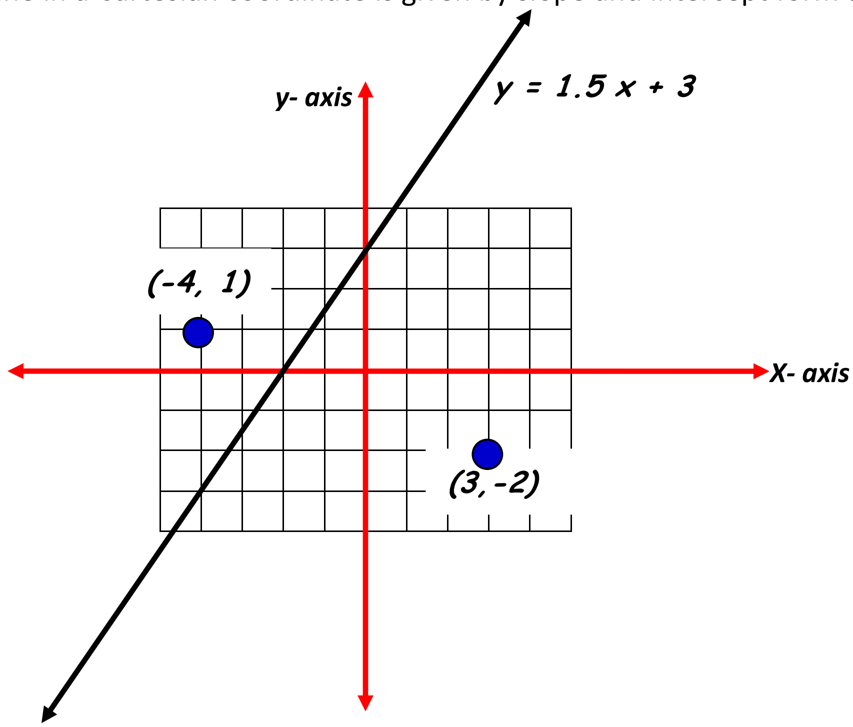
Pattern Drawings with Analytical Equations

Introduction: Equation of straight line

The equation of a straight line in a Cartesian coordinate is given by slope and intercept form as ***y = mx + c***



For example, the equation of the straight line passing through the points (-2, 0) and (0, 3), shown above, is given by **y = 1.5x + 3**.

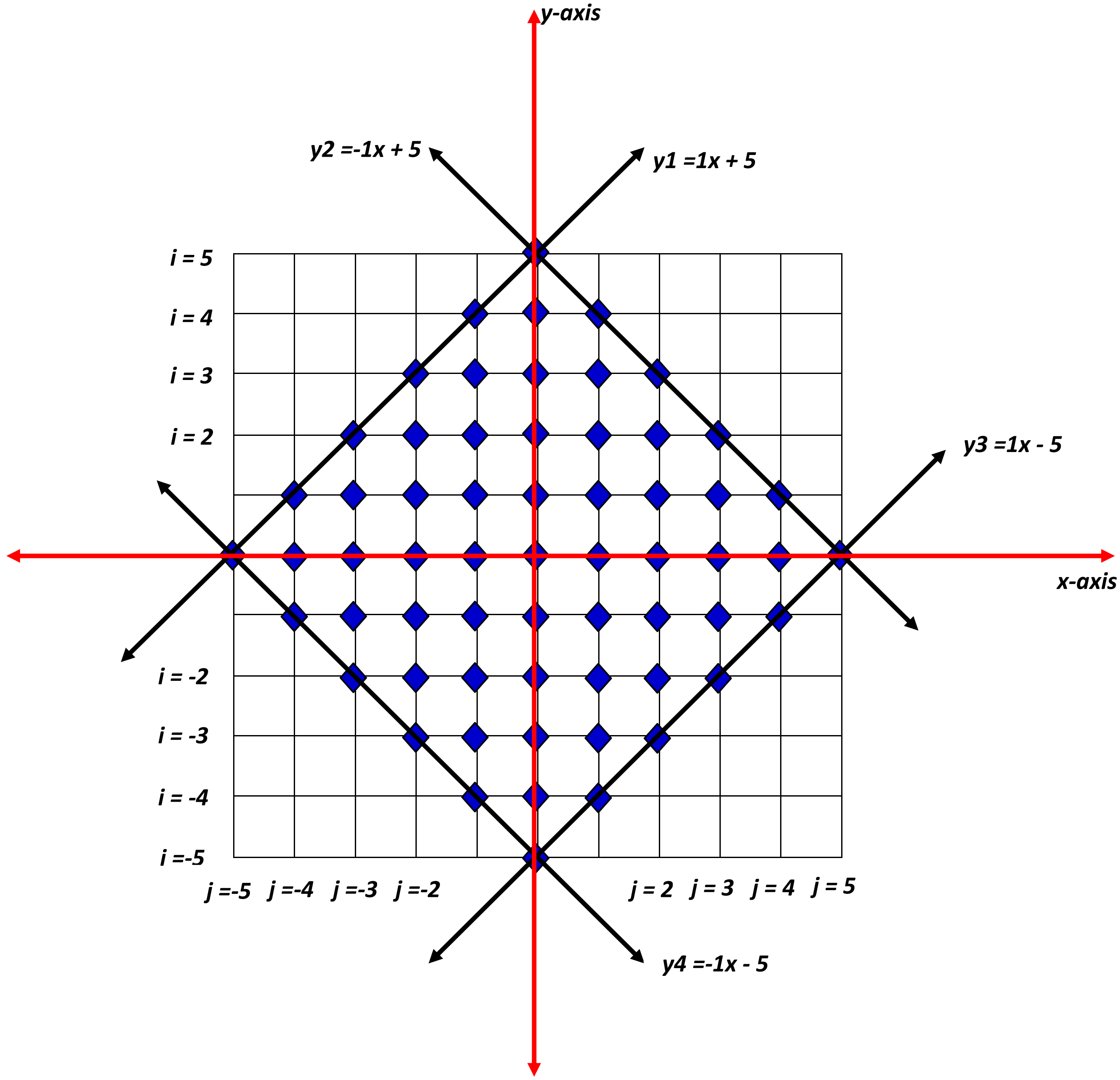
Now consider any point in the Cartesian plane that lies above the given straight line, for example the point **(x1, y1) = (-4, 1)** shown as a blue dot in the diagram above. For this point, we could also use the equation of the line in order to calculate its y-value using its x-value. We see that y = 1.5*-4 + 3 = -3. Now, observe that the value of y1 which is 1 is greater than the calculated y-value which is -3. This is true for every point we pick above the straight line. That is

- For any point that lies above the straight line, its y-value is always greater than the value of y calculated from the equation of the line. Similarly
- For any point that lies below the straight line, its y-value is always less than the value of y calculated from the equation of the line.

Diamond shape pattern in Cartesian coordinate system

Now, let us draw a diamond shape of **asterisks** (star symbol) and super impose it in a Cartesian coordinate system. Following Question #19 in lab work Week 5, we would like to draw a diamond shape that has **2n-1** rows for any given positive integer value **n**. The diagram below shows the case for **n = 6**.

Note that the star (asterisk) symbol is replaced by a blue colored diamond shape for drawing purposes.



Putting It All Together

As you can see in the diagram above, we can draw straight lines along the diagonal shape and also get the equations of the straight lines thanks to the fact that we have super imposed our diamond shape inside a Cartesian coordinate system.

Now, it is easy to see that every asterisk that makes up the diamond shape is below the straight line y1 **AND** below the straight line y2 **AND** above the straight line y3 **AND** above the straight line y4.

Also observe that every asterisk is described by ***(i, j)*** values in our nested loop; where the value of ***j*** represents its ***x-coordinate*** and ***i*** represents its ***y-coordinate***.

Therefore it is easy to see that in order to draw the diamond shape; it is enough to loop with i vertically going from 5 to -5 in the above diagram and with j horizontally from -5 to 5. Then a given (i, j) value in the nested loop lies on an asterisk if

- ***i*** is **less than or equal** to ***y1*** **AND**
- ***i*** is **less than or equal** to ***y2*** **AND**
- ***i*** is **greater than or equal** to ***y3*** **AND**
- ***i*** **is greater than or equal** to ***y4***.

Finally observe that the diamond shape diagram above is specific for n = 6. For any positive integer value n, it is easy to see that the values of y1, y2, y3 and y4 are given as follows:

$y1 = j + n - 1$

$y2 = -j + n - 1$

$y3 = j - (n - 1) = j - n + 1$

$y4 = -j - (n - 1) = -j - n + 1$

Moreover the nested loop will go from (n-1) to -(n-1) for the outer loop and from -(n-1) to (n-1) for the inner loop. Now it is easy to see that the following complete program draws a diamond shape for any positive value of n.

```
#include <iostream>
using namespace std;
int main()
{
	int n;
	do
	{
		cout << "Enter a positive integer n ";
		cin >> n;
	}while (n <= 0);
		int y1, y2, y3, y4;
	for (int i = n-1; i >= -(n-1); i--)
	{
		for (int j = -(n-1); j <= n-1; j++)
		{
			y1 = j + n - 1;
			y2 = -j + n - 1;
			y3 = j - n + 1;
			y4 = -j - n + 1;

			if (i <= y1 && i <= y2 && i >= y3 && i >= y4)
				cout << "*";
			else
				cout << " ";
		}
		cout << endl;
	}
	system("Pause");
	return 0;
}
```

Now it goes without saying you can draw circles (discs), ellipses or other geometrical figures. All you need is their equations and relating your xy coordinates with your nested loops variables. Have fun!