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EXAMPLE: AN INTERACTIVE BASE CONVERTER

Rationale

It is often useful to be able to demonstrate the mechanisms employed in performing number base conversions. In particular, it is useful to demonstrate base conversion where complex bases are involved. With bases higher than 10, the letters A, B, C, D, E, and F are used to represent digits from 10 to 15.

Tools

The demonstration employs the Microsoft EXCEL application package. EXCEL has features that can be exploited to execute this

activity. The features employed include using the VLOOKUP feature to pick the values associated with input digits. The function POWER(base, positional exponent) is used to consolidate the position values using the algorithm:

Number = $\sum digit_j * base^{positional\ value\ of\ digit}$

Methodology

The user is prompted to supply a number to be converted from a given base into base ten. The base of the source number is therefore also input interactively by the user.

The user should enter the number composed of a maximum of four digits one digit per cell in the set of cells in columns EFGH. For each of the digits entered, the application looks up the associated decimal equivalents taking into account that the base could go up to hexadecimal or base sixteen. Accordingly, the lookup table has a mapping for each of the sixteen possible digits 0, 1, ,9, A, ,F.

Table-array

Digit	Decimal

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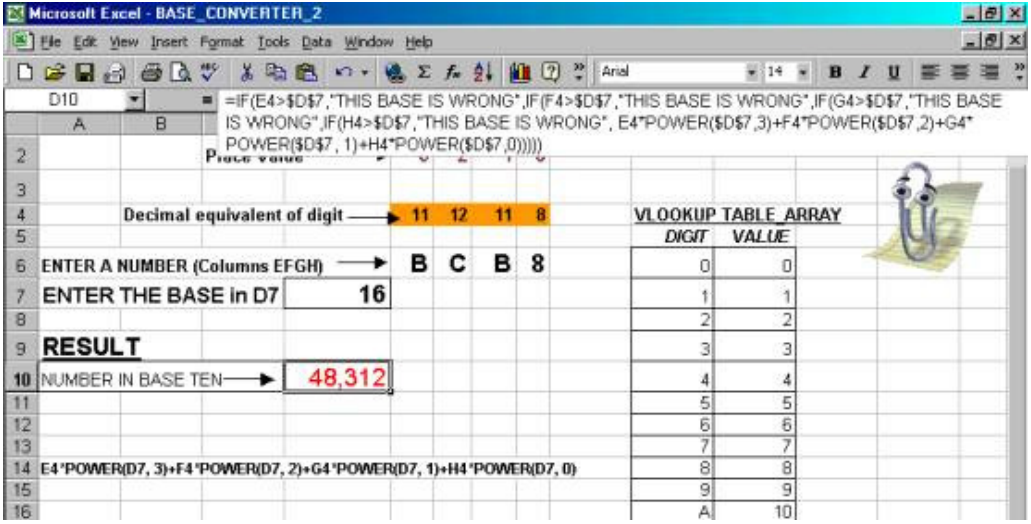
	equivalent
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
A	10
B	11
C	12
D	13
E	14
F	15

The VLOOKUP function accordingly takes the following shape

VLOOKUP(value-to-be-matched, table-array-range, column-of-target-value, k) Where: value-to-be-matches the digit entered by the user and in the formula is represented by the cell address. Table-array-range is the range reference to the lookup table that indicates the decimal equivalent of each digit. Column-of-target-value indicates the column within the table-array where the actual values are stored.



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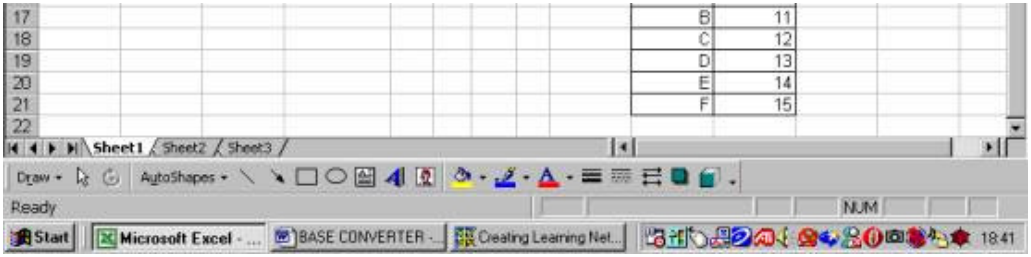

Click here to experiment with the application interactively.

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EXERCISES

Exercise 1:
The table below shows the activity of a certain radioactive isotope.

Time (hrs)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Activity A counts/min	409	358	316	274	250	226	206	180	163	149	129

(a) Plot a graph of Activity against time.

(b) Plot a graph of lnA against time
(where lnA is natural logarithms of A).

See Solution Spreadsheet

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Exercise 2

Exercise 3

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EXAMPLE : Investigation of Properties of Light as it moves from glass to air

i (deg)	5	10	15	20	25	30	35	40	45	50	55	60	65	70
r (deg)	8.0	14.0	22.0	29.0	36.0	44.0	54.0	64.0	90.0	-50	-55	-60	-65	-70

N.B Negative values of (r) indicate that the ray of light is totally internally reflected in glass.

Part 1: Simple Analysis

Plot a graph of angle of refraction (r) against angle of incidence (i) up until the ray reflects.
Note: Negative values of (r) imply that the ray of light is totally internally reflected in glass.

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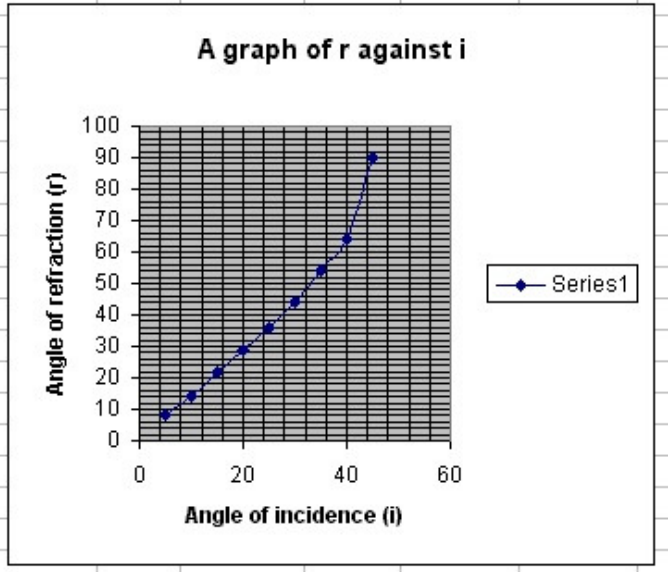
Solving

	A	B	C	D	E	F	G	H
1	Investigate the properties of light as it moves from glass into air							
2								
3	I in degree	r in degrees						
4	5	8						
5	10	14						
6	15	22						
7	20	29						
8	25	36						
9	30	44						
10	35	54						
11	40	64						
12	45	90						
13	50	-50						
14	55	-55						
15	60	-60						
16	65	-65						
17								
18								
19								
20								
21								



Look at the SpreadSheet (Excel)

The graph above shows that the angle of refraction (r) increases as the angle of incidence (i) increases.

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Part 2 : Full Analysis

Plot a graph of sin (r) against sin (i) up until the ray reflects.

Proceed as follows:

(a) Change the angles of incidence(i) and those of refraction (r) from degrees to radians

Hint: 1 degree = PI( ) where PI() is a function to calculate p
180

e.g 20 degrees = PI() x 20 = 0.35
180

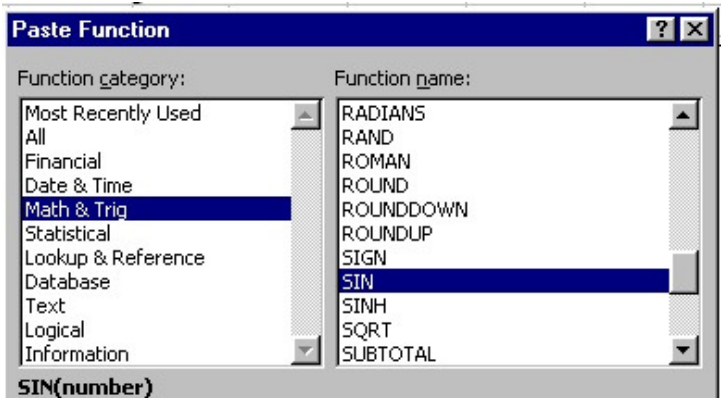
(b) (i) Name the range containing the angles of incidence(i) the "*i*" range.

Use Insert --> Name --> Define from the main menu

(ii) Name the range containing the angles of refraction (r) the "*ref*" range

(c) Calculate the values of the angles of incidence in radians using i * PI()/180 and the angles of refraction

in radians using ref * PI()/180
(d) Use Insert --> Function ---> Math & Trig ---> SIN to paste the SIN() function and
use it to calculate the values of sin (r) and sin (i).



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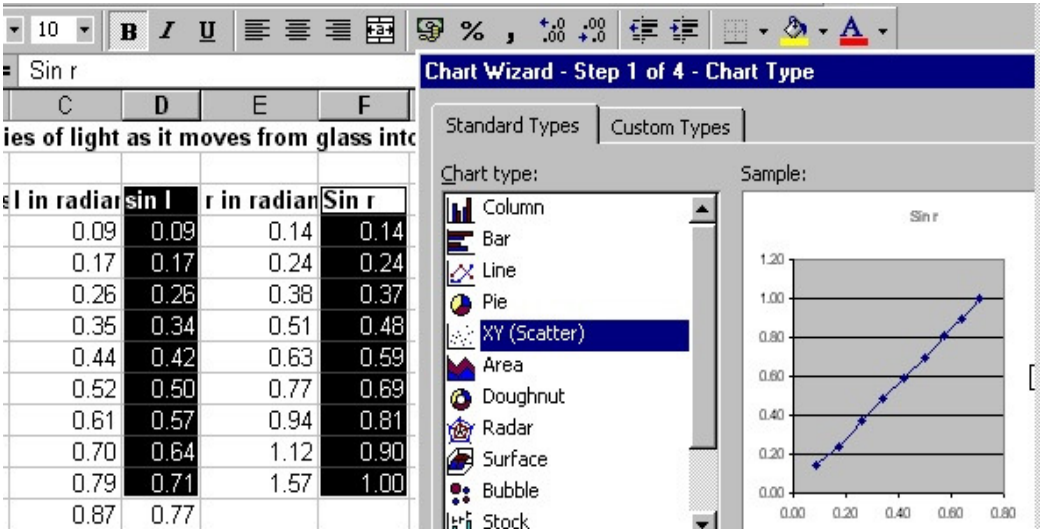
Note in SIN(number), the number must be the angle in radians.

(e) Block the columm for sin (i) and sin (r) and plot the XY (scatter) chart up to when the ray is totally internally reflected in glass.



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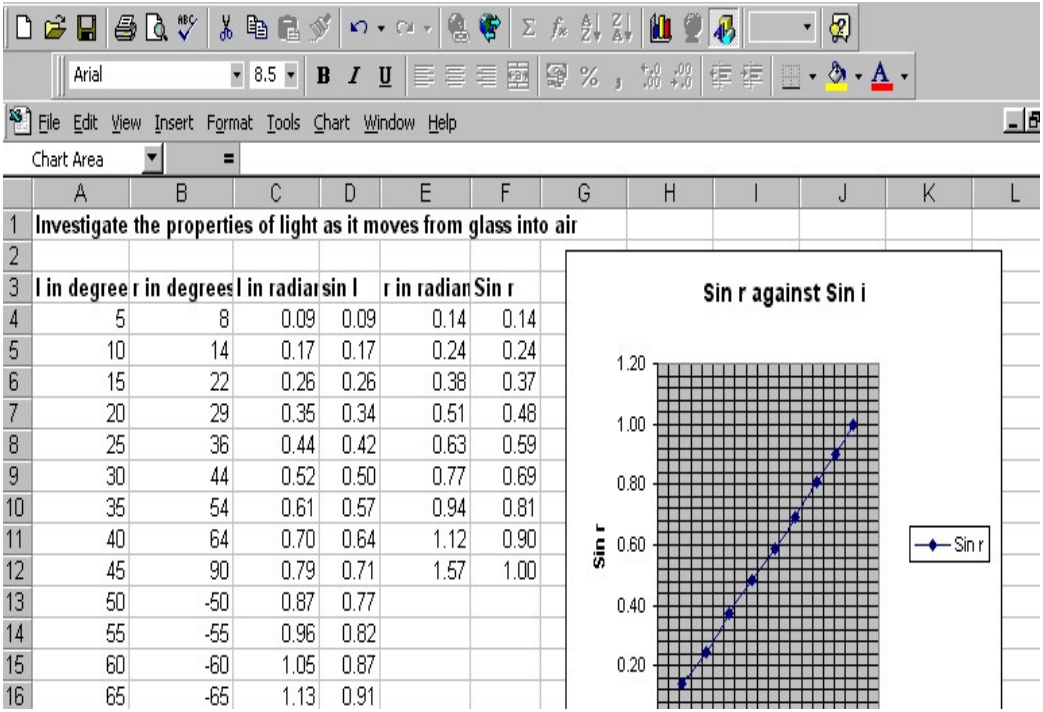
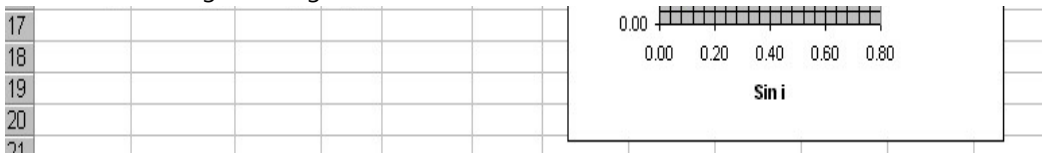
0.96	0.82	
1.05	0.87	
1.13	0.91	

Scatter with data points connected smoothed Lines.

(f) Finish off the steps involved in inserting the chart.





[Take a look at the SpreadSheet (Excel)]

The above graph shows that sin (r) is directly proportional to sin (i).

Sin (r)/Sin (i) = A constant (Snell's law)

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EXAMPLE : SOLVING POLYNOMINAL EQUATIONS

Example: Solve $2x^3 + 6x^2 - 9x - 12 = 0$

Solution:

To solve $2x^3 + 6x^2 - 9x - 12 = 0$, you have first to draw a graph of $y = 2x^3 + 6x^2 - 9x - 12$

PART 1 : Ploting the Graph of $y = 2x^3 + 6x^2 - 9x - 12$

Step 1: Plot a Graph of $y = 2x^3 + 6x^2 - 9x - 12$

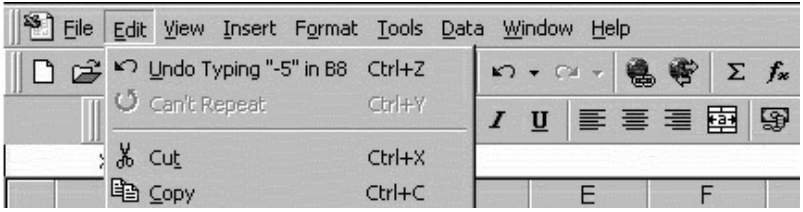
(a) Type **X** in B7 and **Y** in C7

Block the range B8 through B24 and name this range x.
Insert ---> **Name** ----> **Define**

(b) In C8, type the formula **= 2*x^3 + 6*x^2 -9*x -12**

(c) Type -5 in B8
Autofill the cells B8 to B24 in steps of 0.5
Block cells B8 to B24

Edit ---> **Fill** ---> **Series**



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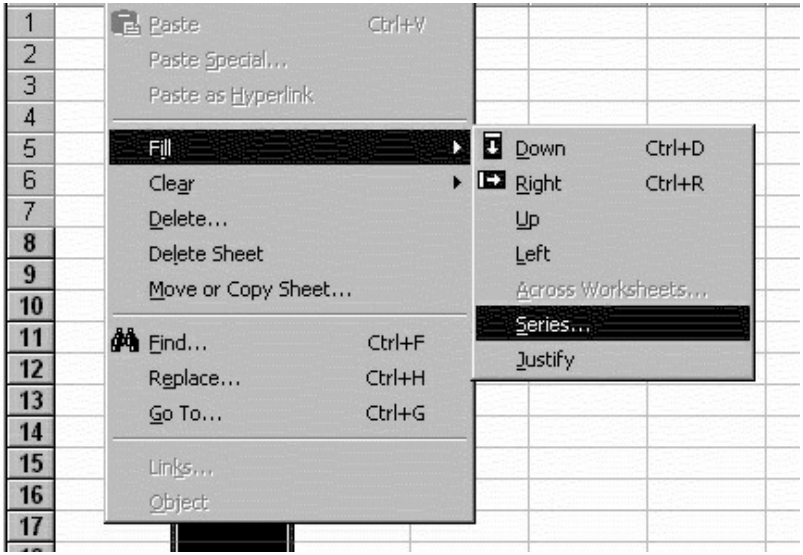

Choose
Series in : **Columns**
Type : **Linear**
Step value : **0.5**
Stop value : **3**

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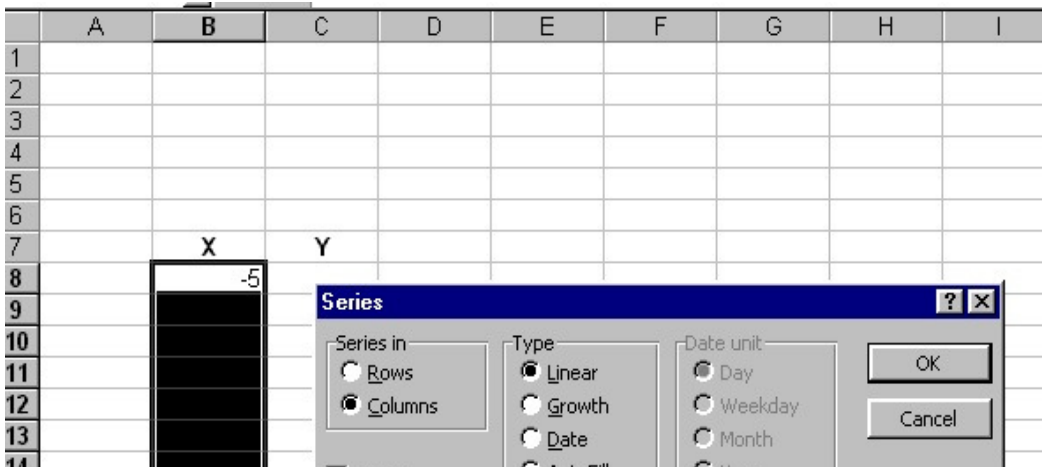

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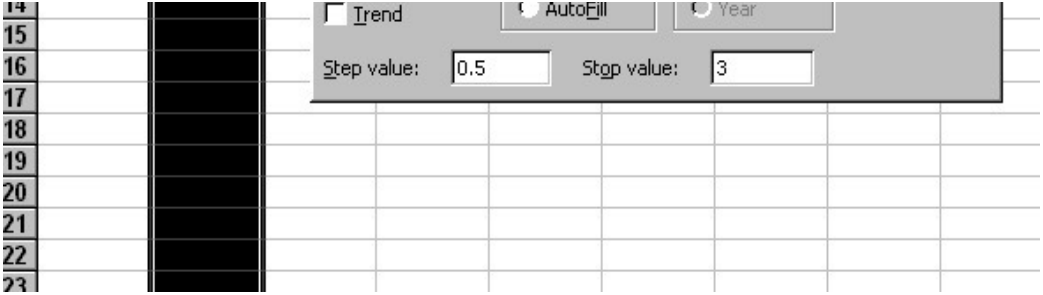
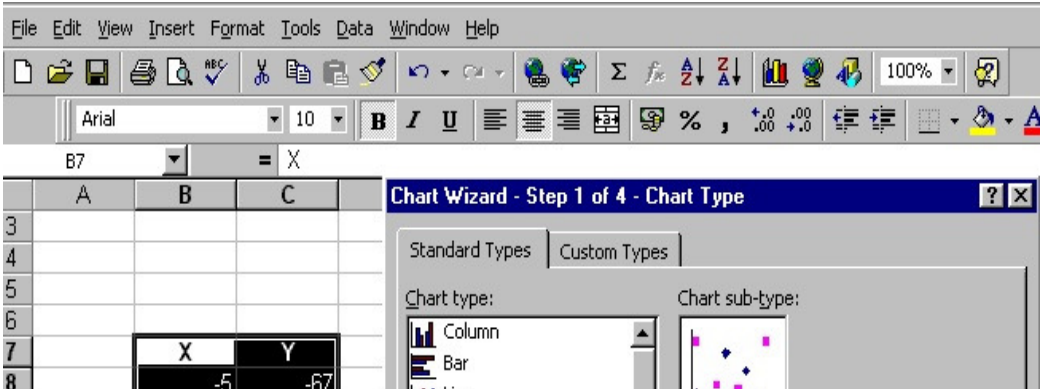


Click **OK**

Copy the formula in C8 and paste it in the range C9 to C24.

(d) Choose the the XY (Scatter) graph type shown below.



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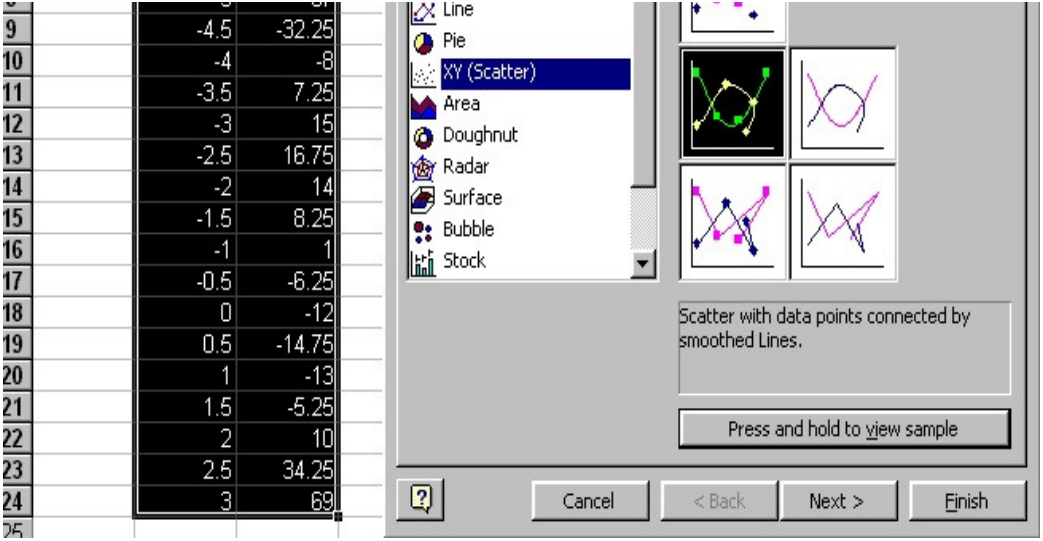
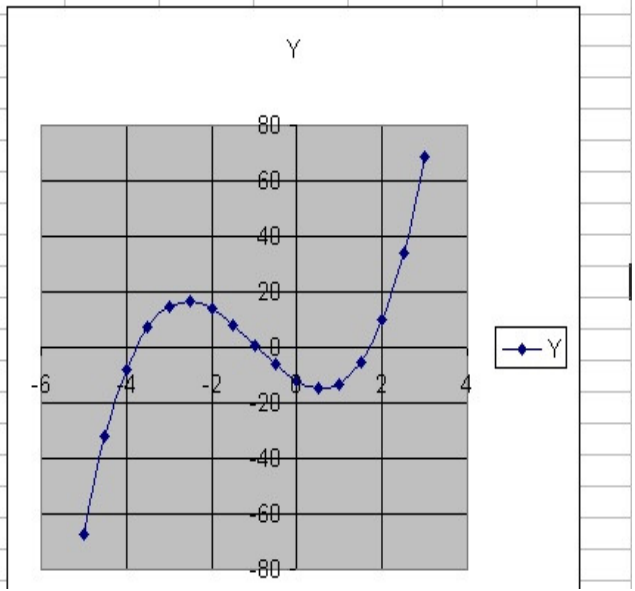


Complete the process of drawing the Chart (graph)
he graph is as shown below

Example : To solve $2x^3 + 6x^2 - 9x - 12 = 0$

Plot a graph of $y = 2x^3 + 6x^2 - 9x - 12$

X	Y
-5	-67
-4.5	-32.25
-4	-8
-3.5	7.25
-3	15
-2.5	16.75
-2	14
-1.5	8.25
-1	1
-0.5	-6.25
0	-12
0.5	-14.75
1	-13
1.5	-5.25
2	10
2.5	34.25
3	69

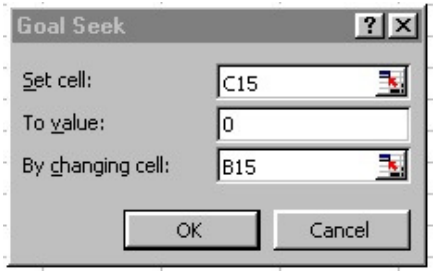


[Link to the Graph.]

Part 2 : Solving $2x^3 + 6x^2 - 9x - 12 = 0$

We need to find the values of x when y = 0 or the intercepts on the X-axis. The graph of $y = 2x^2 + 6x^2 - 9x - 12$ shows that there are three values of x: $\mathbf{x_1}$, $\mathbf{x_2}$ and $\mathbf{x_3}$. Two of these values are negative and one positive.
To find the values x_1, x_2, x_3 use the **Goal Seek** tool under **Tools** on the menu bar.

Goal Seek adjusts the value in a specified cell until a formula that is dependent on that cell reaches a target value



In this case Goal Seek will adjust the value in cell B15 until until the formula in C15 reaches a target value of 0.

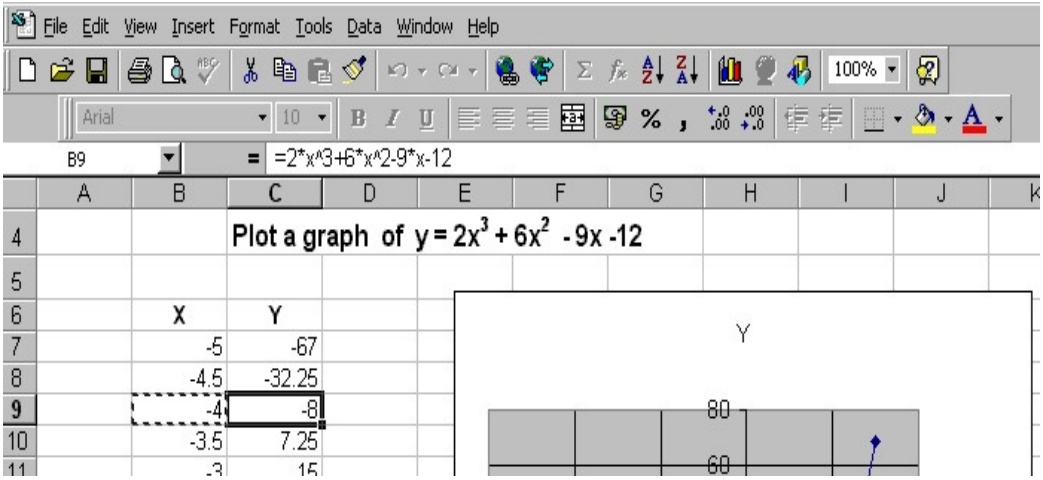
Note:

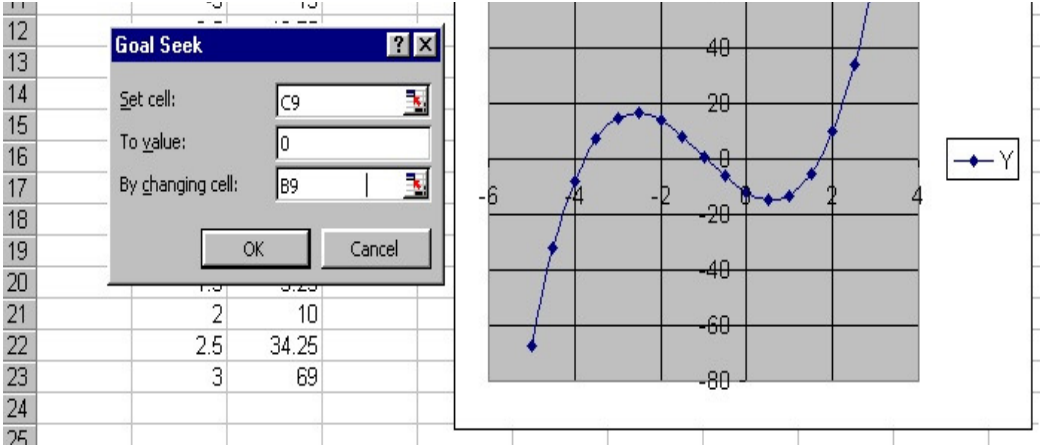
Note:

The values of Y change from:

-8 (negative) in cell C9 to **+7.25 (positive)** in cell C10
1 (positive) in cell C15 to **-6.25 (negative)** in cell C16
-5.25 (negative) in cell C20 to **+10 (positive)** in cell C21

To obtain the values of x: x_1, x_2 and x_3, use the Goal seek tool and set the values in cells C9 or C10, C15 or C16 and C20 or C21 to a target value of 0.

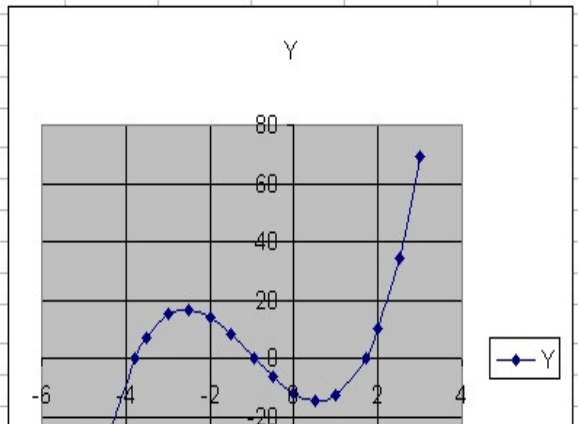


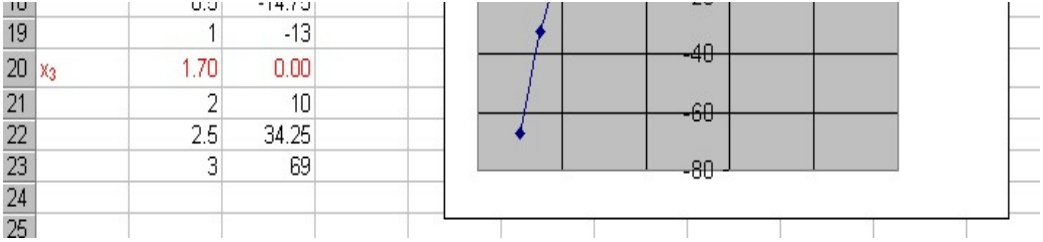


Use the following values

Set cell	C9	C15	C20
To value	0	0	0
By changing cell	B9	B15	B20

	A	B	C
4		Plot a graph of $y = 2x^3 + 6x^2 - 9x - 12$	
5			
6		X	Y
7		-5	-67
8		-4.5	-32.25
9	x_1	-3.77	0.00
10		-3.5	7.25
11		-3	15
12		-2.5	16.75
13		-2	14
14		-1.5	8.25
15	x_2	-0.93	0.00
16		-0.5	-6.25
17		0	-12





[Link to the Graph]

The polynomial $2x^3 + 6x^2 - 9x - 12 = 0$ has three solutions; $x_1 = -3.77$, $x_2 = -0.93$, $x_3 = 1.70$

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