

## 4.2 Linear versus Non-Linear

How can you tell the difference between linear and non-linear?

I First Difference

- linear: first differences are constant (for constant  $\Delta x$ )
- non-linear: first differences are not constant

ex

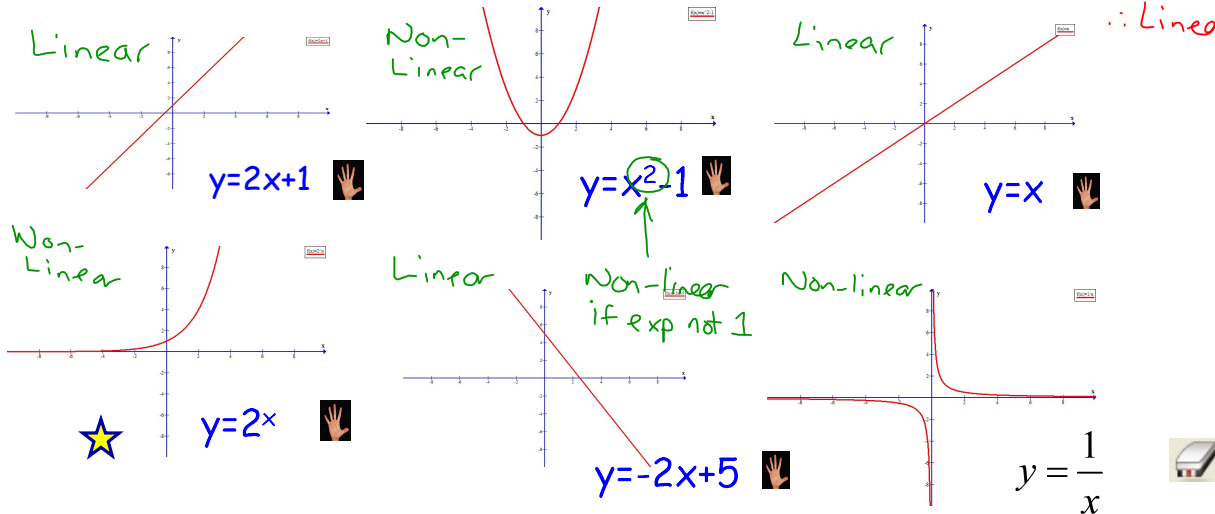
$x$	$y$
0	5
2	10
4	15
6	20

$+2 \downarrow$  (between 0 and 2)  
 $+2 \downarrow$  (between 2 and 4)  
 $+2 \downarrow$  (between 4 and 6)

$\uparrow +5$  (between 5 and 10)  
 $\uparrow +5$  (between 10 and 15)

∴ Linear

II Graphically



III Equations Now look at the above equations

What about this equation?

Pull

All linear equations have

- a degree of 1 (both the x and y variable have an exponent of 1)
- no variables in the denominator

ex:

$y = 3x^4 - 6$  Non-linear

$y = 3^x$  Non-linear

$y = 2x + 7$  Linear

All linear equations can be written in the form  $y = mx + b$  (or  $y = b$  or  $x = a$ ).

Ex. 1 Linear or Non-linear?

- a)  $y = -4x - 2$   
Linear
- b)  $y = 2x^2 + 1$   
Non-linear
- c)  $2x - 3y + 4 = 0$   
Linear



Notice that a linear equation can be written in different ways...

Ex. 2 Linear or Non-linear? Find the equation in c)

If linear, find the equation

a)

Distance (m) <i>m</i>	Speed (m/s) <i>S</i>
0	20
1	16
2	12
3	8
4	4

ROC  
 $\frac{-4}{1} = -4$

$S = -4m + 20$

b)

Time (s) <i>t</i>	Height (m) <i>H</i>
10	14
15	16
20	18
25	20
30	22

$m = \frac{2}{5}$

$H = \frac{2}{5}t + 10$

c)

x	y
0	6
1	9
2	12
3	15
4	18
7	27

$m = \frac{\Delta y}{\Delta x} = \frac{3}{1} = 3$

$m = \frac{9}{3} = 3$

It IS linear!

$y = 3x + 6$

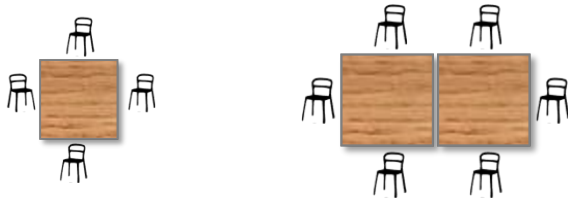
d)

Day	Population
0	13
1	14
2	17
3	22
4	29

Non-linear

Ex. 3

At a square table, 4 people can be seated on each side. When two tables are joined together, as seen below, 6 people can be seated.



Number of Tables	Number of Seats
1	4
2	6
3	8
4	10
5	12

$\sum$   
 $n$

$+2$   
 $+2$   
 $+2$   
 $+2$

a) Complete the table of values

b) Does this show linear growth?

Yes! Constant  $\frac{\Delta y}{\Delta x}$

c) If 12 tables were joined how many people could be seated? Use an equation.

$$S = 2n + 2$$

Sub  $n=12$

$$S = 2(12) + 2$$

$$= 24 + 2$$

$$= 26$$

$\therefore$  There would be 26 chairs.

Ex. 4 After calculating first differences for the table of values on the right, Samantha concluded that the relationship between length and width is non-linear. Is Samantha correct? Explain.

L	W
1	5.1
2	8.8 $> +3.7$
3	12.5 $> +3.7$
4	16.2 $> +3.7$
5	19.9 $> +3.7$

Not in order!  $\rightarrow$

Length (cm)	Width (cm)
1	5.1
3	12.5
2	8.8
5	19.9
4	16.2

$$\frac{\Delta y}{\Delta x} = \frac{12.5 - 5.1}{3 - 1}$$

$$= \frac{7.4}{2}$$

$$= 3.7$$

$\therefore$  It IS linear!  
Sam is not correct.