Objectives: I can model a quadratic relationship with a function table and graph.

Quadratic Functions

Another type of non-linear function is a quadratic function. The shape is called a parabola which looks kind of like a U. We frequently see this type of function when gravity affects an object jumping or being thrown. We will explore a couple of situations that can be represented with a quadratic function.

T	$-16t^2+40t+4$		H
0	$-16(0)^2+40(0)+4$	$0+0+4$	4
.25	$-16(.25)^2+40(.25)+4$	$-1+10+4$	13
.5	$-16(.5)^2+40(.5)+4$	$-4+20+4$	20
.75	$-16(.75)^2+40(.75)+4$	$-9+30+4$	25
1	$-16(1)^2+40(1)+4$	$-16+40+4$	28
1.25	$-16(1.25)^2+40(1.25)+4$	$-25+50+4$	29
1.5	$-16(1.5)^2+40(1.5)+4$	$-36+60+4$	28
1.75	$-16(1.75)^2+40(1.75)+4$	$-49+70+4$	25
2.	$-16(2.)^2+40(2.)+4$	$-64+80+4$	20
2.25	$-16(2.25)^2+40(2.25)+4$	$-81+90+4$	13
2.5	$-16(2.5)^2+40(2.5)+4$	$-100+100+4$	4

No matter how hard you kick or throw a ball into the air, gravity always returns it to Earth. In this problem, you will see how the height of a football changes over time.

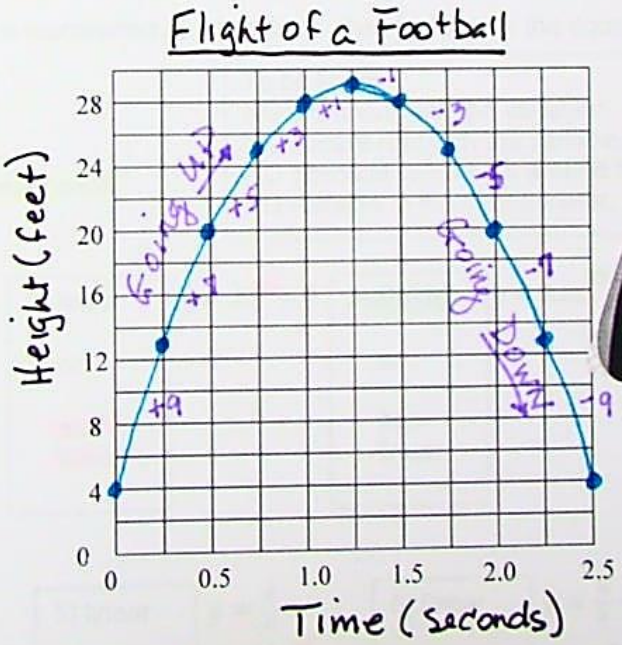
Suppose you filmed a ball as it is thrown straight up as high as possible. If you studied the films frame by frame, you would find that the time, t, in seconds and the H, height, in feet are related by an equation similar to this:

t = time (seconds)
H = the height (feet)

Football Equation: $\mathbf{H = -16t^2 + 40t + 4}$

1. Complete the table and graph for the relationship. (Round the height to the nearest tenth of a foot.)

Time (seconds)	Height (feet)	
0.0	4	+9
0.25	13	+7
0.5	20	+5
0.75	25	+3
1.0	28	+1
1.25	29	−1
1.5	28	−3
1.75	25	−5
2.0	20	−7
2.25	13	−9
2.5	4	



2. Describe the pattern of change for the ball in the height over time, and explain how the pattern is reflected in the table or the graph.

When the ball is thrown, the height of it increases rapidly but lessens over time until it reaches its maximum height, then the height decreases slowly at first, then more rapidly until it is caught 4ft off the ground.

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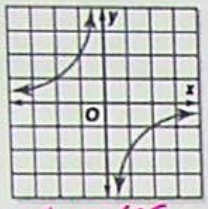
Linear or Nonlinear

straight

Graph: If the relationship is represented as a graph, then a line is linear ... curves mean "non-linear"

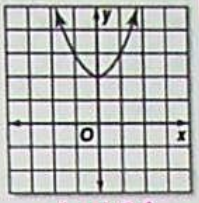
Circle the correct response for each.

1) linear or **non-linear**



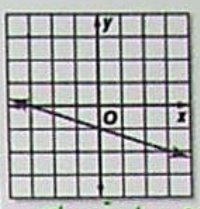
Curves

2) linear or **non-linear**



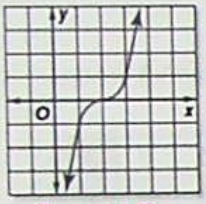
curve (parabola)

3) **linear** or non-linear



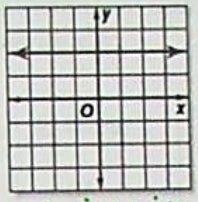
straight LINE

4) linear or **non-linear**



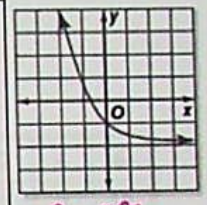
Curves

5) **linear** or non-linear



straight LINE

6) linear or **non-linear**



Curve

Equation: If the relationship is represented as an equation, then try to write the equation in slope-intercept form or $y = mx + b$.

To be linear....
- NO exponent with the variables
- NO square root with the variables
- NO absolute value bars around the variables
- NO variable in the denominator

Circle the correct response for each.

1) linear or **non-linear** $y = x^3 - 1$

2) linear or **non-linear** $y = 4x^2 + 9$

3) **linear** or non-linear $y = 0.6x$

4) **linear** or non-linear $y = \frac{3x}{2}$

5) linear or **non-linear** $y = \frac{4}{x}$ $y = 4x^{-1}$

6) linear or **non-linear** $y = \frac{8}{x} + 5$ $y = 8x^{-1} + 5$

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Table: If the relationship is represented as a table, then the rate of change must be the same through the table. If the rate of change is constant this is called the slope in a linear relationship.

x	y
2	50
4	35
6	20
8	5

+2, +2, +2 ; −15, −15, −15

As x increases by 2, y decreases by 15 each time. The rate of change is constant, so this function is linear.

x	y
1	1
4	16
7	49
10	100

+3, +3, +3 ; +15, +33, +51

$\frac{15}{3}$ $\frac{33}{3}$ $\frac{51}{3}$

$5 \neq 11 \neq 17$

As x increases by 3, y increases by a greater amount each time. The rate of change is not constant, so this function is nonlinear.

Circle the correct response for each.

1) (linear) or non-linear

x	0	5	10	15
y	20	16	12	8

+5; −4, −4, −4

$\frac{-4}{5}$ = slope (constant rate of change)

2) linear or (non-linear)

x	0	2	4	6
y	0	2	8	18

+2, +2, +2 ; +2, +6, +10

$\frac{2}{2} \neq \frac{6}{2} \neq \frac{10}{2}$

Rate of change NOT constant!

3) (linear) or non-linear

x	0	3	6	9
y	−3	9	21	33

+3; +12, +12, +12

$\frac{12}{3} = \frac{4}{1}$ = slope (constant rate of change)

4) linear or (non-linear)

Length (in.)	1	4	8	10
Width (in.)	64	16	8	6.4

+3, +4, +2; −48, −8, 1.6

$-\frac{48}{3} \neq -\frac{8}{4} \neq \frac{1.6}{2}$

$-16 \neq -2 \neq 0.8$

Rate of change is NOT constant!

Practice. **Determine whether each table, graph, or equation represents a *linear* or *nonlinear* function. Explain.**

1.

x	0	1	2	3
y	1	3	6	10

+1; +2, +3, +4

Nonlinear — not constant!

2.

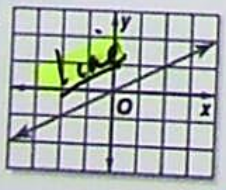
x	0	3	6	9
y	−3	9	21	33

+3; +12, +12, +12

$\frac{12}{3} = 4$ (slope)

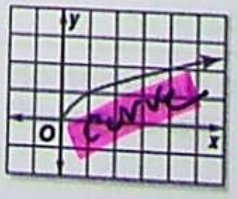
LINEAR — constant rate of change!

3.



linear

4.



nonlinear

5. $y = \frac{x}{3}$ $y = \frac{1}{3}x$ slope!

linear

6. $y = 2x^2$

nonlinear