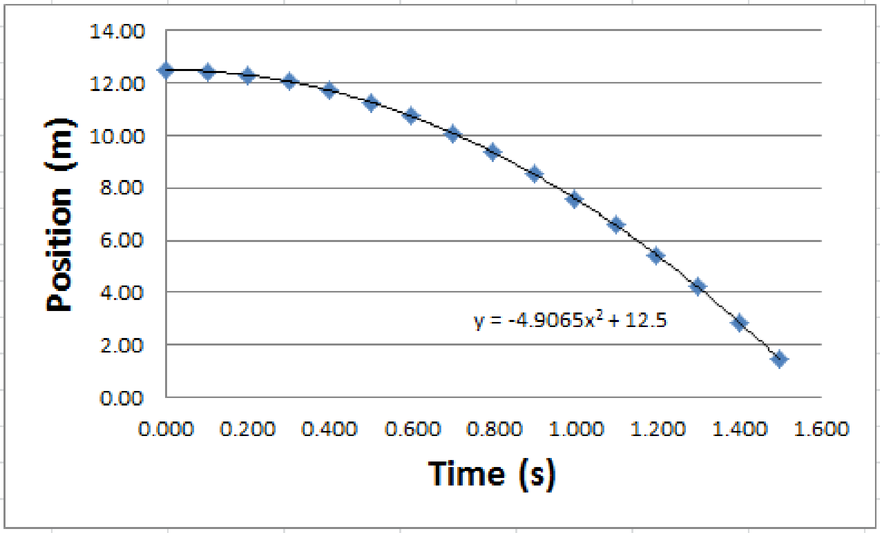
Look over the data and scatter plots below, and complete the following prompts and questions using the trendlines generated for you. (Note: Air resistance is ignored for these problems.)

1. The data below belongs to a brick that is falling straight down.

time (s)	position (m)
0.000	12.50
0.100	12.45
0.200	12.30
0.300	12.06
0.400	11.71
0.500	11.27
0.600	10.73
0.700	10.10
0.800	9.36
0.900	8.53
1.000	7.59
1.100	6.56
1.200	5.43
1.300	4.21
1.400	2.88
1.500	1.46

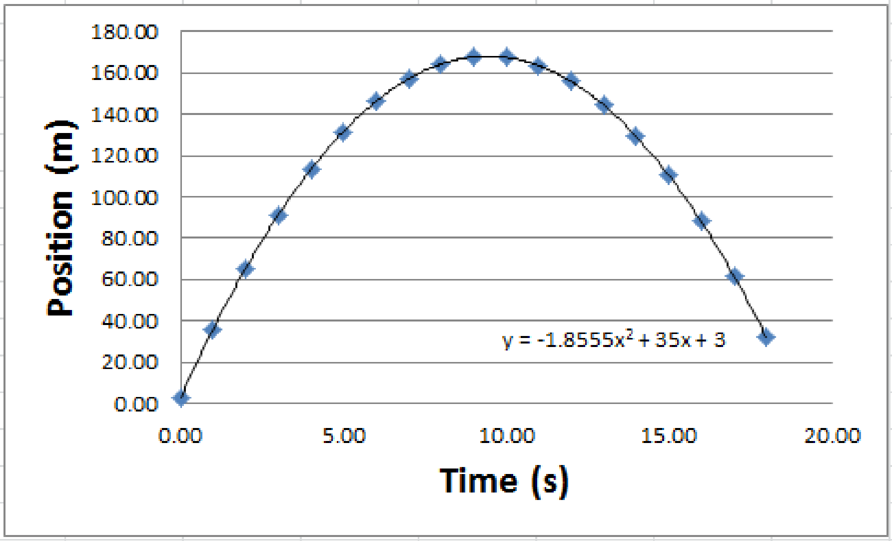


a) Write out two models (for x_f and v_f) governing the motion of this brick.
b) What was the brick's initial velocity? Its acceleration?
c) What was the brick's velocity at t = 0.950 s?
d) What was the brick's displacement (not position) at t = 0.750 s?
e) Extrapolate to find the time at which the brick hits the ground.

a) $\mathbf{x_f} = (-4.9065\,\mathbf{j})t^2 + 12.5\,\mathbf{j}$, $\mathbf{v_f} = (-9.813\,\mathbf{j})t$
b) $\mathbf{v_i} = 0$ (m/s) , $\mathbf{a} = -9.813\,\mathbf{j}$ (m/s/s)
c) $\mathbf{v_f} = (-9.813\,\mathbf{j})0.950 =$ $-9.322\,\mathbf{j}$ (m/s)
d) $\mathbf{x_f} = (-4.9065\,\mathbf{j})0.750^2 + 12.5\,\mathbf{j} = 9.74\,\mathbf{j}$ (m); $\mathbf{\Delta x} = \mathbf{x_f} - \mathbf{x_i} = 9.74\,\mathbf{j} - 12.50\,\mathbf{j} =$ $-2.76\,\mathbf{j}$ (m)
e) $\mathbf{x_f} = 0$; $0 = (-4.9065\,\mathbf{j})t^2 + 12.5\,\mathbf{j}$; $-12.5\,\mathbf{j} = (-4.9065\,\mathbf{j})t^2$; t = 1.596 (s)

2. The data below belongs to a rock that was thrown straight up.

time (s)	position (m)
0.00	3.00
1.00	36.14
2.00	65.58
3.00	91.30
4.00	113.31
5.00	131.61
6.00	146.20
7.00	157.08
8.00	164.25
9.00	167.70
10.00	167.45
11.00	163.48
12.00	155.81
13.00	144.42
14.00	129.32
15.00	110.51
16.00	87.99
17.00	61.76
18.00	31.82



a) Write out two models (for x_f and v_f) governing the motion of this rock.
b) What was the rock's initial velocity? Its acceleration?
c) Can you determine where this rock was thrown, using the Internet?
d) At what time did the rock reach its highest point above the ground (its peak)?
e) At what time will it land? (Assume its final position is 0.00 meters.)
f) At what two times was the rock 150.00 m above the ground?
g) What was the rock's position at t = 5.55 s? What was its displacement at this time?
h) What was the velocity of the rock at t = 4.00 s?
i) What was the velocity of the rock at its peak?
j) What was the velocity of the rock at t = 16.00 s?

a) $\mathbf{x}_f = (-1.8555\,\mathbf{j})t^2 + (35.00\,\mathbf{j})t + 3.00\,\mathbf{j}$, $\mathbf{v}_f = (-3.711\,\mathbf{j})t + 35.00\,\mathbf{j}$
b) $\mathbf{v}_i = 35.00\,\mathbf{j}$ (m/s) , $\mathbf{a} = -3.711\,\mathbf{j}$ (m/s/s)
c) Mars
d) the peak is reached when $\mathbf{v}_f = 0$; $0 = (-3.711\,\mathbf{j})t + 35.00\,\mathbf{j}$; $t = 9.43$ (s)
e) $\mathbf{x}_f = 0$; $0 = (-1.8555\,\mathbf{j})t^2 + (35.00\,\mathbf{j})t + 3.00\,\mathbf{j}$; $t = \frac{35\pm\sqrt{-35^2-4(1.8555)(-3.00)}}{2(1.8555)} = 18.95$ (s)
f) $\mathbf{x}_f = 150.00\,\mathbf{j}$ (m); $150\,\mathbf{j} = (-1.8555\,\mathbf{j})t^2 + (35.00\,\mathbf{j})t + 3.00\,\mathbf{j}$; $t = \frac{35\pm\sqrt{-35^2-4(1.8555)(147.00)}}{2(1.8555)} = 6.31$ and 12.55 (s)
g) $\mathbf{x}_f = (-1.8555\,\mathbf{j})5.55^2 + (35.00\,\mathbf{j})5.55 + 3.00\,\mathbf{j} = 140.10\,\mathbf{j}$ (m)

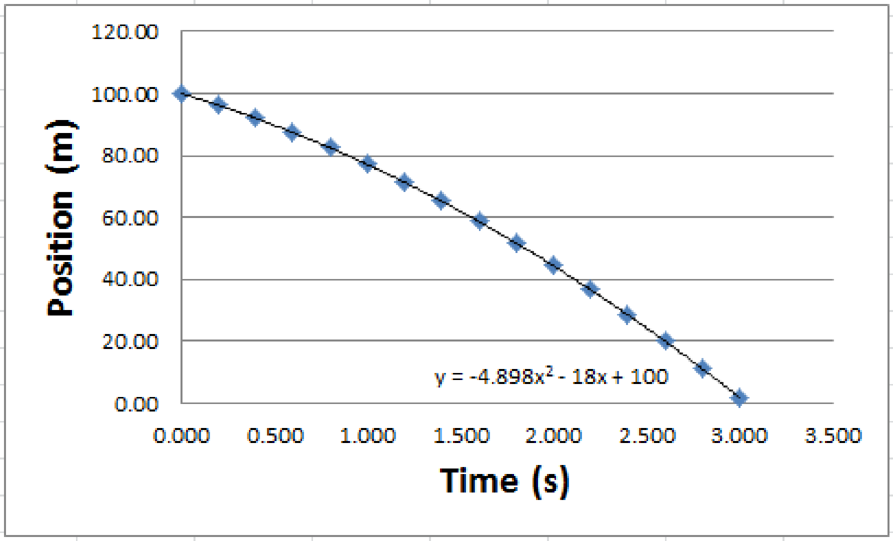
h) $\mathbf{v_f}$ = (-3.711 $\mathbf{j}$)4.00 + 35.00 $\mathbf{j}$ = 20.16 $\mathbf{j}$ (m/s)

i) $\mathbf{v_f}$ = 0 (m/s) at the peak, by definition

j) $\mathbf{v_f}$ = (-3.711 $\mathbf{j}$)16.00 + 35.00 $\mathbf{j}$ = -24.38 $\mathbf{j}$ (m/s)

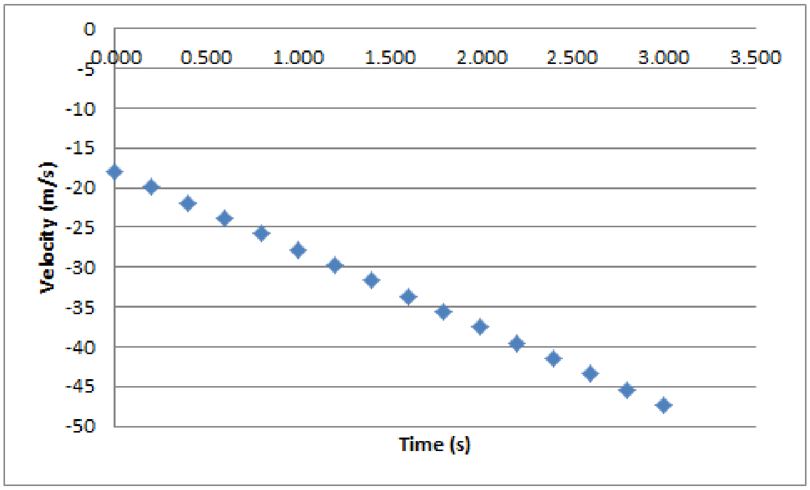
3. The data below belongs to a baseball. It was either thrown upward, thrown downward, or dropped, but it was not thrown forward.

time (s)	position (m)
0.000	100.00
0.200	96.20
0.400	92.02
0.600	87.44
0.800	82.47
1.000	77.10
1.200	71.35
1.400	65.20
1.600	58.66
1.800	51.73
2.000	44.41
2.200	36.69
2.400	28.59
2.600	20.09
2.800	11.20
3.000	1.92



a) Write out two models (for x_f and v_f) governing the motion of this baseball.
b) What was the baseball's initial velocity? Its acceleration?
c) Was the baseball thrown upward, thrown downward, or dropped?
d) What was the velocity of the baseball at t = 1.000 s?
e) Sketch a graph of the ball's *velocity vs time*. Include numbers and labels on the two axes.
f) What was the displacement (not position) of the ball at t = 2.350 s?
g) At what time did the ball land? (Assume its final position is 0.00 meters.)
h) What initial velocity would produce a flight time exactly twice as long? (Assume the same starting position.)

a) $\mathbf{x_f} = (-4.898\ \mathbf{j})t^2 + (-18.00\ \mathbf{j})t + 100.00\ \mathbf{j}$, $\mathbf{v_f} = (-9.796\ \mathbf{j})t + (-18.00\ \mathbf{j})$
b) $\mathbf{v_i} = -18.00\ \mathbf{j}$ (m/s) , $\mathbf{a} = -9.796\ \mathbf{j}$ (m/s/s)
c) given that $\mathbf{v_i}$ is negative, the baseball was thrown downward
d) $\mathbf{v_f} = (-9.796\ \mathbf{j})1.000 + (-18.00\ \mathbf{j}) =$ -27.80 $\mathbf{j}$ (m/s)

e) 

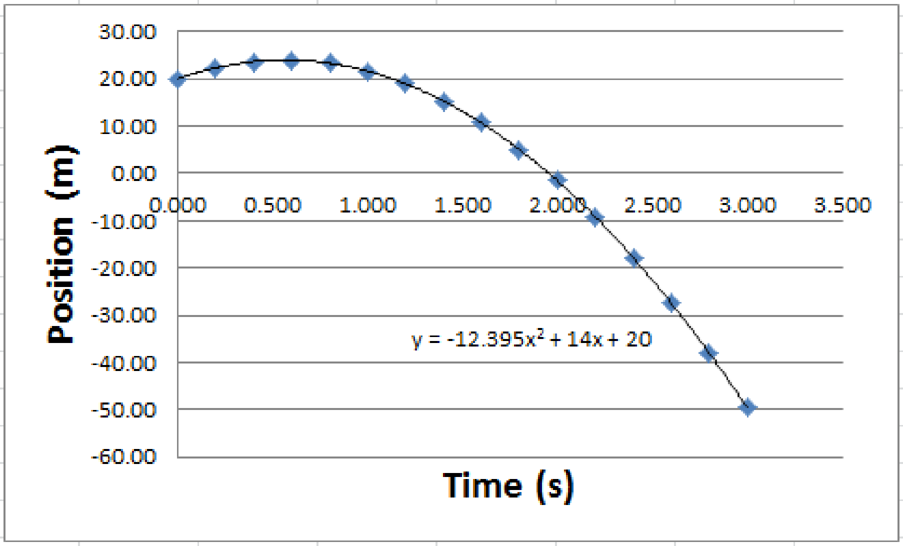
f) $\mathbf{\Delta x} = \mathbf{x}_f - 100.00\,\mathbf{j} = (-4.898\,\mathbf{j})2.350^2 + (-18.00\,\mathbf{j})2.350 =$ **-69.35 j (m)**

g) $\mathbf{x}_f = 0$; $0 = (-4.898\,\mathbf{j})t^2 + (-18.00\,\mathbf{j})t + 100.00\,\mathbf{j}$; $t = \frac{-18 \pm \sqrt{18^2 - 4(4.898)(-100.00)}}{2(4.898)}$ = **3.040 (s)**

h) twice as long = 6.080 seconds; using the model of $\mathbf{x}_f$, with $\mathbf{x}_f = 0$ and the -18.00 **j** replaced with the variable $\mathbf{v}_i$, $0 = (-4.898\,\mathbf{j})6.080^2 + (\mathbf{v}_i)6.080 + 100.00\,\mathbf{j}$; $\mathbf{v}_i =$ **13.33 j (m/s)**

4. The data below belongs to a non-metallic piece of space debris. Assume its motion is entirely vertical.

time (s)	position (m)
0.000	20.00
0.200	22.30
0.400	23.62
0.600	23.94
0.800	23.27
1.000	21.61
1.200	18.95
1.400	15.31
1.600	10.67
1.800	5.04
2.000	-1.58
2.200	-9.19
2.400	-17.80
2.600	-27.39
2.800	-37.98
3.000	-49.56



a) Write out two models (for x_f and v_f) governing the motion of this object.
b) What was the object's initial velocity? Its acceleration?
c) Is our object on or near Earth? Can you determine where it might be, using the Internet?
d) How much time does our object spend moving upward?
e) At what time does our object reach a position of -20.00 meters?
f) What is the object's displacement at the moment it reaches a position of -20.00 meters?
g) At what time does our object have a velocity of -15.23 m/s?
h) At what time does our object have a displacement of zero?
i) What is the position (not displacement) of the object at t = 2.700 s?

a) $\mathbf{x_f} = (-12.395\ \mathbf{j})t^2 + (14.00\ \mathbf{j})t + 20.00\ \mathbf{j}$, $\mathbf{v_f} = (-24.79\ \mathbf{j})t + (14.00\ \mathbf{j})$
b) $\mathbf{v_i} = 14.00\ \mathbf{j}$ (m/s) , $\mathbf{a} = -24.79\ \mathbf{j}$ (m/s/s)
c) This matches the local acceleration at the "surface" of Jupiter.
d) the peak is reached when $\mathbf{v_f} = 0$; $0 = (-24.79\ \mathbf{j})t + (14.00\ \mathbf{j})$; t = 0.565 (s)
e) $\mathbf{x_f} = -20.00\ \mathbf{j}$ (m); $-20.00\ \mathbf{j} = (-12.395\ \mathbf{j})t^2 + (14.00\ \mathbf{j})t + 20.00\ \mathbf{j}$; $t = \frac{14 \pm \sqrt{-14^2 - 4(12.395)(-40.00)}}{2(12.395)} =$ 2.448 (s)
f) $\Delta\mathbf{x} = \mathbf{x_f} - \mathbf{x_i} = -20.00\ \mathbf{j} - 20.00\ \mathbf{j} = -40.00\ \mathbf{j}$ (m)
g) $\mathbf{v_f} = -15.23\ \mathbf{j}$ (m/s); $-15.23\ \mathbf{j} = (-24.79\ \mathbf{j})t + (14.00\ \mathbf{j})$; t = 1.179 (s)
h) $\mathbf{x_f} = 20\ \mathbf{j}$ (m) results in $\Delta\mathbf{x} = 0$; $0 = (-12.395\ \mathbf{j})t^2 + (14.00\ \mathbf{j})t$; t = 1.129 (s)
i) $\mathbf{x_f} = (-12.395\ \mathbf{j})2.700^2 + (14.00\ \mathbf{j})2.700 + 20.00\ \mathbf{j} = -32.56\ \mathbf{j}$ (m)