We will finish up 1.5 first, then check 1.4 HW, go over 1.5 HW questions, and start 1.6.

Part 2: Falling, Falling, Falling

When the astronauts went to the moon, they performed Galileo's experiment to test the idea that any two objects, no matter their mass, will fall at the same rate if there is no air resistance (like on the moon). Because the moon doesn't have air resistance, we are going to pretend like we're the astronauts dropping moon rocks and thinking about what happens. On the surface of the moon the constant acceleration increases the speed of a falling object by 6 feet per second each second. That is, if an object is dropped near the surface of the moon (e.g., its initial speed is zero when $t = 0$), then the object's instantaneous speed after 1 second is 6 feet per second, after 2 seconds, its instantaneous speed is 12 feet per second, and so on.

1. Using this information, create a table for the speed of an object that is dropped from a height of 200 feet above the surface of the moon as a function of the elapsed time (in seconds) since it was dropped.

$d = \text{speed} \times \text{time}$

time	speed (6t)	avg. speed	total distance travelled*	height above moon
0	0	0	0	200
1	6	$\frac{0+6}{2} = 3$	$3(1) = 3$	197
2	12	$\frac{0+12}{2} = 6$	$3 \cdot 2(2) = 12$	188
3	18	$\frac{0+18}{2} = 9$	$3 \cdot 3(3) = 27$	173
4	24	$24/2 = 12$	$3 \cdot 4(4) = 48$	152
5	30	$30/2 = 15$	$3 \cdot 5(5) = 75$	125
6	36	$36/2 = 18$	$3 \cdot 6(6) = 108$	92
7	42	$42/2 = 21$	$21(7) = 147$	53
8	48	$48/2 = 24$	$24(8) = 192$	8
9	54	$\frac{54}{2} = 27$	$27(9) = 243$	-43
t	6t		$3t^2$	$200 - 3t^2$

First differences of distance: 3, 9, 15, 21, 27; second differences: 6, 6, 6, 6 — Quad

2. Add another column to your table to keep track of the distance the object has fallen as a function of elapsed time. Explain how you are finding these distances.

distance = avg. speed × time

3. Approximately how long will it take for the object to hit the surface of the moon?

≈ 8 sec.

4. Write an equation for the distance the object has fallen as a function of elapsed time t.

$d = 3t^2$

-OR-

$d(t) = 3t^2$

5. Write an equation for the height of the object above the surface of the moon as a function of elapsed time *t*.

$h = 200 - 3t^2$

-OR- $h(t) = 200 - 3t^2$

7. How is your work on these *falling objects problems* related to your work with the *rabbit runs?*

$d = 3t^2$

$h = 200 - 3t^2$

quadratic

Area: $36\ell - \ell^2$

8. Why are the "distance fallen" and "height above the ground" functions quadratic?

degree 2

same second difference

parabola when graphed

1.5 HW Questions?

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Find the indicated value of the function for each value of x. $x = \{-2, -1, 0, 1, 2, 3\}$

1. $f(x) = 3^x$
2. $g(x) = 5^x$
3. $h(x) = 10^x$

$k(3) = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

$k(0) = \left(\frac{1}{2}\right)^0 = 1$

$k(1) = \left(\frac{1}{2}\right)^1 = \frac{1}{2}$

$k(2) = \left(\frac{1}{2}\right)^2 = \frac{1^2}{2^2} = \frac{1}{4}$

4. $k(x) = \left(\frac{1}{2}\right)^x$

5. ~~$m(x) = \left(\frac{1}{3}\right)^x$~~

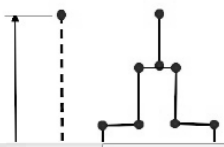
$k(-2) = \left(\frac{1}{2}\right)^{-2} = \frac{1^{-2}}{2^{-2}} = \frac{2^2}{1^2} = 4$

$k(-1) = \left(\frac{1}{2}\right)^{-1} = \frac{2^1}{1^1} = 2$

Set

The Sears Tower in Chicago is 1730 feet tall. If a penny were let go from the top of the tower, th position above the ground *s(t)* of the penny at any given time *t* would be $s(t) = -16t^2 + 1730$.

6. Fill in the missing positions in the chart. Then add to get the distance fallen.



Distance from ground

a. ______ 1 sec
b. ______ 2 sec
c. ______ 3 sec
d. ______ 4 sec

7. How far above the ground is the penny when 7 seconds have passed?

8. How far has it fallen when 7 seconds have

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Find the indicated value of the function for each value of x. $x = \{-2, -1, 0, 1, 2, 3\}$

1. $f(x) = 3^x$

2. $g(x) = 5^x$

3. $h(x) = 10^x$

$h(-2) = 10^{-2}$

$= \frac{1}{10^2} = \frac{1}{100}$

4. $k(x) = \left(\frac{1}{2}\right)^x$

5. $m(x) = \left(\frac{1}{3}\right)^x$

$h(2) = 10^2 = 100$

Set

The Sears Tower in Chicago is 1730 feet tall. If a penny were let go from the top of the tower, th
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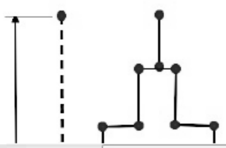

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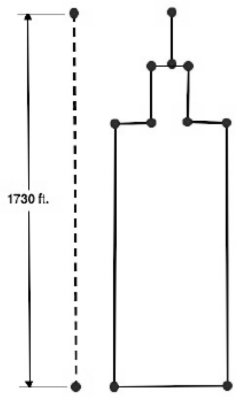
The Sears Tower in Chicago is 1730 feet tall. If a penny were let go from the top of the tower, the position above the ground *s(t)* of the penny at any given time *t* would be $s(t) = -16t^2 + 1730$.

$(-2)^2$ vs. (-2^2)

6. Fill in the missing positions in the chart. Then add to get the distance fallen.

$s(2) = -16(2)^2 + 1730 = 1666$



Distance from ground

a. ______ 1 sec
b. ______ 2 sec
c. ______ 3 sec
d. ______ 4 sec
e. ______ 5 sec
f. ______ 6 sec
g. ______ 7 sec
h. ______ 8 sec
i. ______ 9 sec
j. ______ 10 sec

7. How far above the ground is the penny when 7 seconds have passed?

8. How far has it fallen when 7 seconds have passed?

$s(6) = -16(6)^2 + 1730$

9. Has the penny hit the ground at 10 seconds? Justify your answer.

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20. *Find* $g(-3)$ *given that* $g(x) = x^2 + 2x + 4$.

$g(-3) = (-3)^2 + 2(-3) + 4 = 9 - 6 + 4 = 7$

21. *Find* $h(-11)$ *given that* $h(x) = 2x^2 + 9x - 43$.

22. *Find* $r(-1)$ *given that* $r(x) = -5x^2 - 3x + 9$.

23. *Find* $s\left(\frac{1}{2}\right)$ *given that* $s(x) = x^2 + \frac{5}{4}x - \frac{1}{2}$.

24. *Find* $p(3)$ *given that* $p(x) = 5^x + 2x$.

25. *Find* $q(2)$ *given that* $q(x) = 7^x + 11x$

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1.6 The Tortoise and the Hare

A Solidify Understanding Task

In the children's story of the tortoise and the hare, the hare mocks the tortoise for being slow. The tortoise replies, "Slow and steady wins the race." The hare says, "We'll just see about that," and challenges the tortoise to a race. The distance from the starting line of the hare is given by the function:

Quadratic

$d = t^2$ (d in meters and t in seconds)

$d(1) = 1^2 = 1$ $d(2) = 2^2 = 4$ $d(3) = 3^2 = 9$ $d(4) = 4^2 = 16$ $d(5) = 5^2 = 25$

Because the hare is so confident that he can beat the tortoise, he gives the tortoise a 1 meter head start. The distance from the starting line of the tortoise including the head start is given by the function:

Exponential

$d = 2^t$ (d in meters and t in seconds)

$d(1) = 2^1 = 2$ $d(2) = 2^2 = 4$ $d(3) = 2^3 = 8$ $d(4) = 2^4 = 16$ $d(5) = 2^5 = 32$

1. At what time does the hare catch up to the tortoise?

   At $t = 2$ seconds

2. If the race course is very long, who wins: the tortoise or the hare? Why?

3. At what time(s) are they tied?

   $t = 2$ and $t = 4$

4. If the race course were 15 meters long who wins, the tortoise or the hare? Why?

5. Use the properties $d = 2^t$ and $d = t^2$ to explain the **speeds** of the tortoise and the hare in the following time intervals:

Interval	Tortoise $d = 2^t$	Hare $d = t^2$
[0, 2)		
[2, 4)		
[4 ,∞)		

Homework/Classwork

Finish 1.6