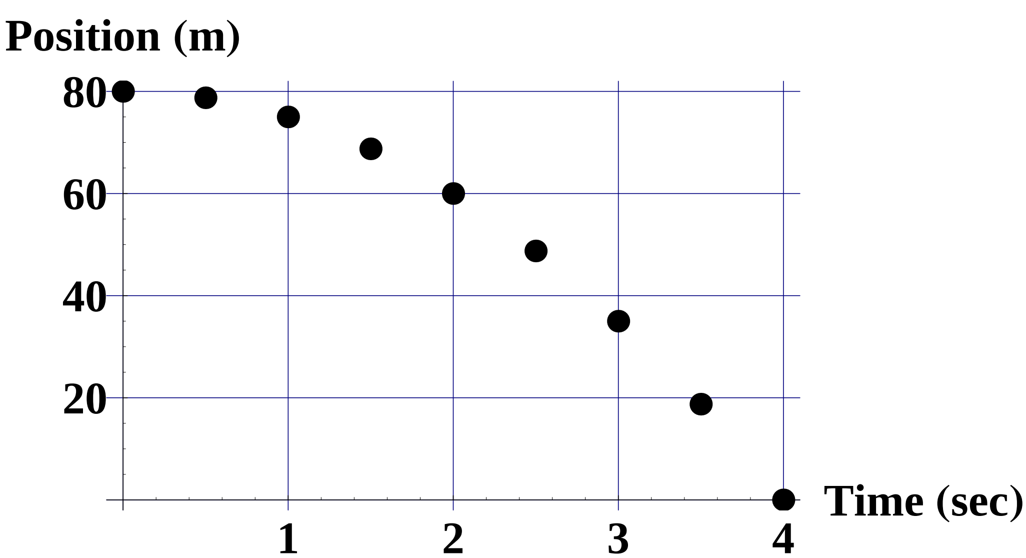
1 Computing Velocity from Position

Velocity is change of position per time unit. (Change of position is distance traveled, denoted in miles, feet, km, or m. Thus velocity is measured in dimensions such as miles/hr, feet/sec, or m/sec.) Let's consider the following example, describing the fall of an object from an initial height of 80 m:

Time (sec)	Position (m)
0.0	80.00
0.5	78.75
1.0	75.00
1.5	68.75
2.0	60.00
2.5	48.75
3.0	35.00
3.5	18.75
4.0	0.00



During the first half-second, the object changes its position from 80 m to 78.75 m, a change of -1.25 m, consequently the *average velocity during the first half-second* equals

$$\frac{78.75 \text{ m} - 80.00 \text{ m}}{0.5 \text{ sec} - 0.0 \text{ sec}} = \frac{-1.25 \text{ m}}{0.5 \text{ sec}} = -2.5 \text{ m/sec}.$$

During the second half-second, the object changes its position from 78.75 m to 75.00 m, a change of -3.75 m, consequently the *average velocity during the second half-second* equals

$$\frac{75.00 \text{ m} - 78.75 \text{ m}}{1.0 \text{ sec} - 0.5 \text{ sec}} = \frac{-3.75}{0.5} \frac{\text{m}}{\text{sec}} = -7.5 \text{ m/sec}.$$

If we continue in this fashion, we obtain the following table for the object's velocity:

Time (sec)	Velocity (m/sec)
0.5	-2.5
1.0	-7.5
1.5	-12.5
2.0	-17.5
2.5	-22.5
3.0	-27.5
3.5	-32.5
4.0	-37.5

2 Computing Acceleration from Velocity

Acceleration is change of velocity per time unit. (Change of velocity is a difference of two velocities, denoted in miles/hr, feet/sec, km/hr, or m/sec. Thus acceleration is measured in dimensions such as miles/hr^2, feet/sec^2, or m/sec^2.) Let's continue our example:

From 0.5 sec to 1 sec, the object changes velocity from -2.5 m/sec to -7.5 m/sec, a change of -5 m/sec; thus the acceleration during that time period is given by

$$\frac{-7.5 \text{ m/sec} - (-2.5 \text{ m/sec})}{1.0 \text{ sec} - 0.5 \text{ sec}} = \frac{-5}{0.5} \frac{\text{m/sec}}{\text{sec}} = -10 \text{ m/sec}^2.$$

If you repeat the computation, you will notice that the acceleration is constant; it is indeed a fundamental property of falling objects, that their acceleration is constant. (Here we are neglecting air resistance!) Close to the surface of the earth, **objects fall with a constant acceleration** of about -10 m/sec^2, or equivalently -32 ft/sec^2.

3 Reversing the Process: Computing Position from Acceleration

Suppose you stand on a platform 50 m high and throw a basketball vertically into the air with an average velocity $v(0.5)$ of 12.5 m/sec during the first half-second.

The basketball experiences a constant acceleration of -10 m/sec^2. Consequently its average velocity $v(1)$ during the second half-second can be computed as follows:

$$\frac{v(1) - v(0.5)}{0.5 \text{ sec}} = -10 \text{ m/sec}^2,$$

so $v(1) = v(0.5) - 10 \text{ m/sec}^2 \cdot 0.5$ sec=7.5 m/sec. Since the ball's acceleration is constant, the ball loses 5 m/sec of its velocity per half-second, leading to the following table:

Time (sec)	Velocity (m/sec)
0.5	12.5
1.0	7.5
1.5	2.5
2.0	-2.5
2.5	-7.5
3.0	-12.5
3.5	-17.5
4.0	-22.5

We know the ball's initial position $y(0)$=50 m, and its velocity during the first half-second. Thus we can compute the position $y(0.5)$ of the ball after the first half-second as follows:

$$\frac{y(0.5) - y(0)}{0.5 \text{ sec}} = 12.5 \text{ m/sec},$$

so $y(0.5) = y(0) + 12.5$ m/sec$\cdot$0.5 sec=56.25 m. Repeating the procedure leads to the following table:

Time (sec)	Position (m)
0.0	50.00
0.5	56.25
1.0	60.00
1.5	61.25
2.0	60.00
2.5	56.25
3.0	50.00
3.5	41.25
...	...

I hope this example looks familiar!