Physics 2A

Chapter 2: Motion in One Dimension

Kinematics
Position
Instantaneous and Average Velocity
Instantaneous and Average Acceleration
Motion Diagrams and x, v, and a Graphs
Free Fall

Kinematics

⇒ Kinematics is the description of the motion of objects (without reference to the forces producing the motion).

⇒ In Chapters 1 and 2, we are restricting our study of motion in 3 ways:

1) The motion is along a straight line only

2) The cause of motion (forces) not discussed

3) All objects are treated as particles

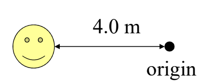
Position

position ⇒ vector quantity that describes where an object is with respect to a reference point (origin)

⇒ In one dimensional motion, direction is indicated by + or -.

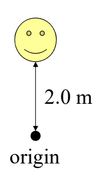
⇒ Unless otherwise stated, we will assume that to the right is + (in the x direction) and up is + (in the y direction).

Position



$x = -4.0\,\text{m}$

⇒ The object is 4.0 m to the left of the origin.



$y = +2.0\,\text{m}$

⇒ The object is 2.0 m above the origin.

Representing Position

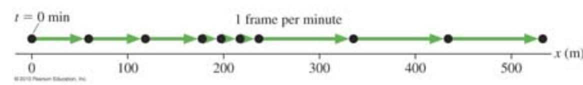
⇒ There are different ways to represent position. One way is to present the data in a table.

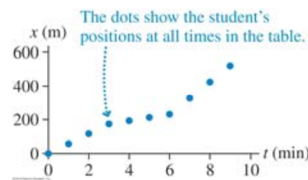
TABLE 2.1 Measured positions of a student walking to school

Time t (min)	Position x (m)	Time t (min)	Position x (m)
0	0	5	220
1	60	6	240
2	120	7	340
3	180	8	440
4	200	9	540

Representing Position

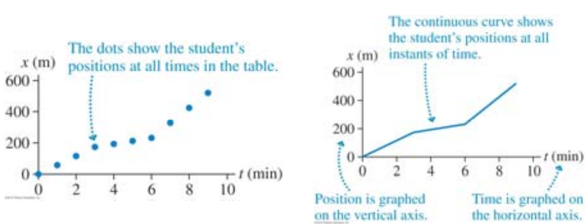
⇒ Another way is with a motion diagram as we saw in Chapter 1.





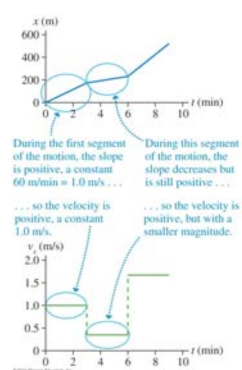
⇒ A third way is with a graph of x versus t.

Representing Position



⇒ Assuming that the student moved continuously through all points of space, we can make the graph a continuous curve called a **position-versus-time graph**.

Average and Instantaneous Velocity

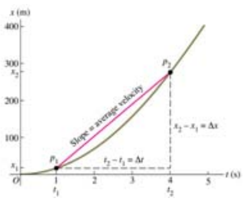


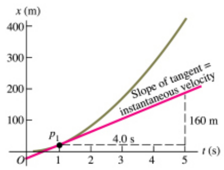
⇒ Remember that velocity is defined as displacement divided by time interval:

$$v_x = \frac{\Delta x}{\Delta t}$$

⇒ We can therefore get the velocity of an object from the slope of the position-time graph.

Average and Instantaneous Velocity



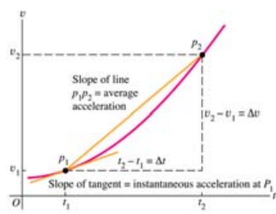


Given a plot of *x* versus *t*:

⇒ The average velocity (between 2 times) is equal to the slope of the line that connects the two points.

⇒ The instantaneous velocity (at a given time) is equal to the slope of the tangent line.

Average and Instantaneous Acceleration

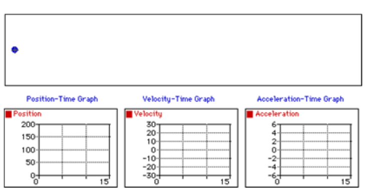


Given a plot of *v* versus *t*:

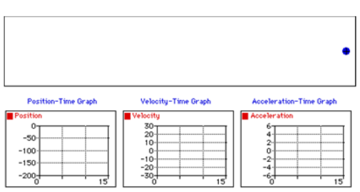
⇒ The average acceleration (between 2 times) is equal to the slope of the line that connects the two points.

⇒ The instantaneous acceleration (at a given time) is equal to the slope of the tangent line.

Position, Velocity, and Acceleration

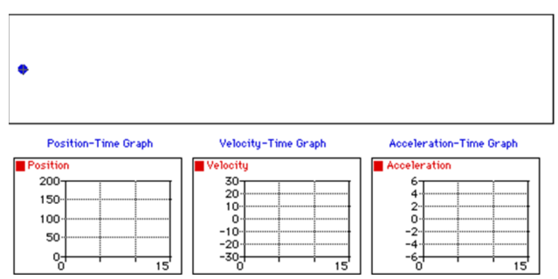


velocity > 0
acceleration = 0



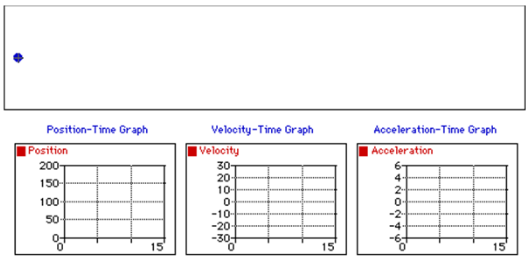
velocity < 0
acceleration = 0

Position, Velocity, and Acceleration



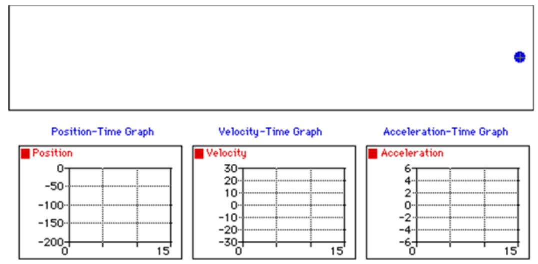
velocity > 0
acceleration > 0

Position, Velocity, and Acceleration



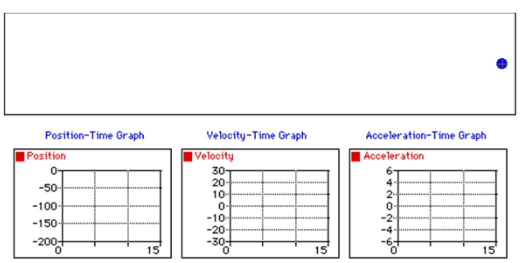
velocity > 0
acceleration < 0

Position, Velocity, and Acceleration



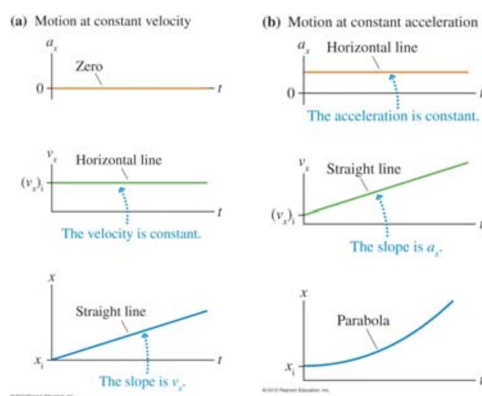
velocity < 0
acceleration > 0

Position, Velocity, and Acceleration

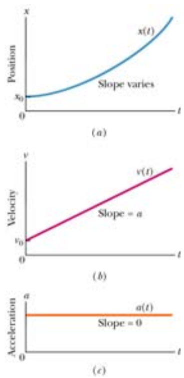


velocity < 0
acceleration < 0

Position, Velocity, and Acceleration



Equations of Constant Acceleration



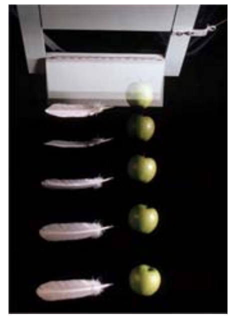
Equations of constant acceleration:

$$(v_x)_f = (v_x)_i + a_x \Delta t$$

$$x_f = x_i + (v_x)_i \Delta t + \tfrac{1}{2} a_x (\Delta t)^2$$

$$(v_x)_f^2 = (v_x)_i^2 + 2a_x \Delta x$$

Freefall

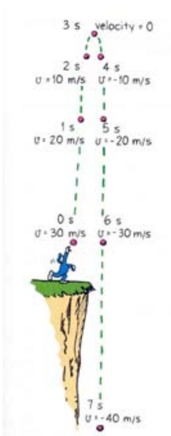


⇒ Without air resistance (in *freefall*), all objects accelerate at the same rate, regardless of their mass or size.

⇒ Near the Earth's surface, the acceleration due to gravity is $-9.80\ \mathrm{m/s^2}$

⇒ The distance between successive images increases as the object's speed increases (at a rate of 9.8 m/s every second).

Freefall



Freefall motion is symmetric:

⇒ time up = time down (assuming $y = y_0$)

⇒ speed at a given height is the same on the way up as it is on the way down (velocities are different)

This can sometimes be very useful in problem solving.