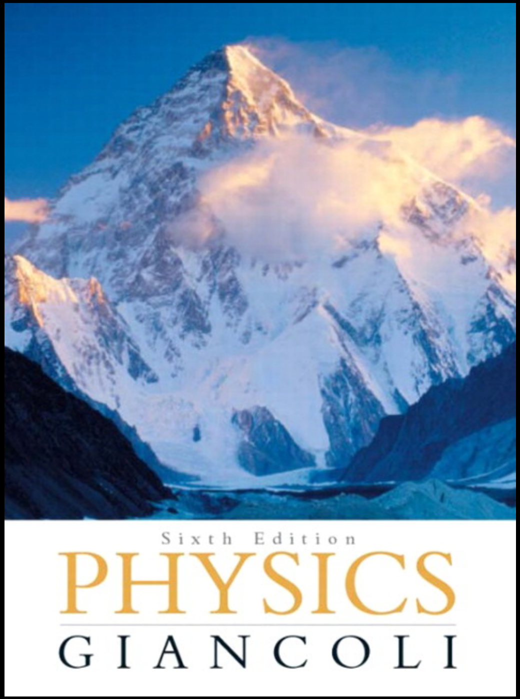


Lecture PowerPoints

Chapter 2

Physics: Principles with Applications, 6th edition

Giancoli

Chapter 2

Describing Motion: Kinematics in One Dimension

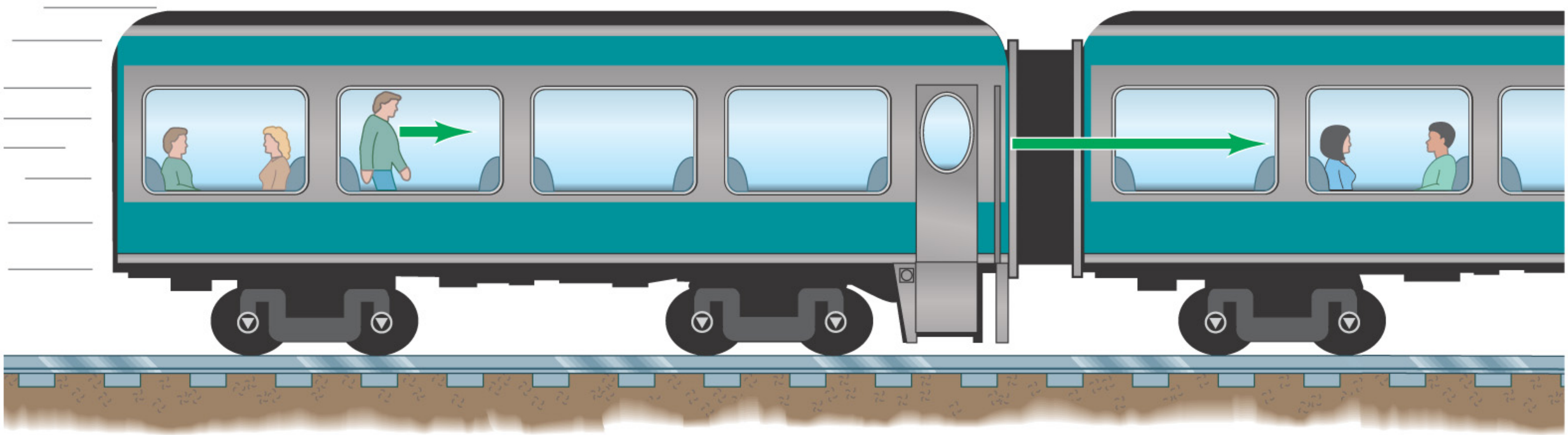
Units of Chapter 2

- **Reference Frames and Displacement**
- **Average Velocity**
- **Instantaneous Velocity**
- **Acceleration**
- **Motion at Constant Acceleration**
- **Solving Problems**
- **Falling Objects**
- **Graphical Analysis of Linear Motion**

2-1 Reference Frames and Displacement

Any measurement of position, distance, or speed must be made with respect to a reference frame.

For example, if you are sitting on a train and someone walks down the aisle, their speed with respect to the train is a few miles per hour, at most. Their speed with respect to the ground is much higher.

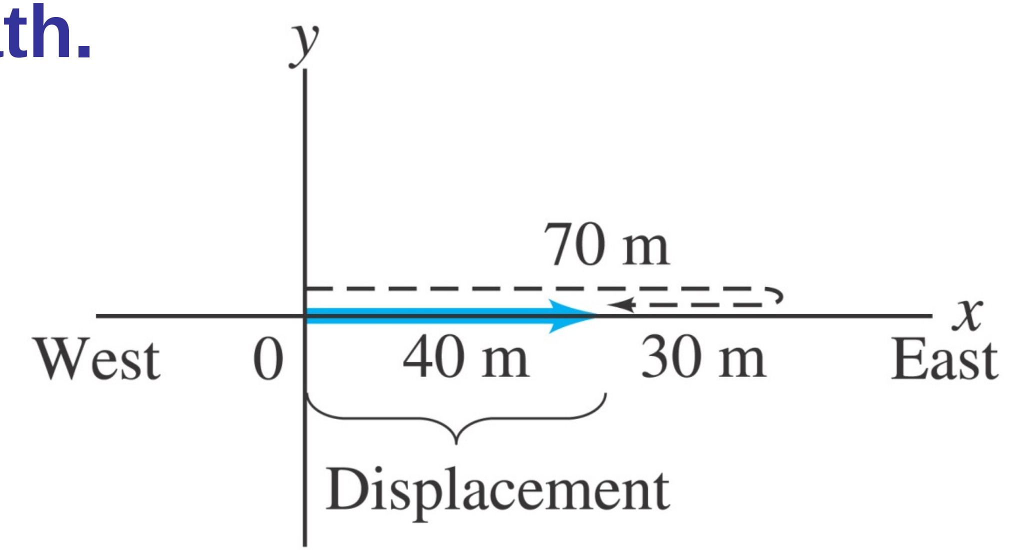


2-1 Reference Frames and Displacement

We make a distinction between distance and displacement.

Displacement (blue line) is how far the object is from its starting point, regardless of how it got there.

Distance traveled (dashed line) is measured along the actual path.

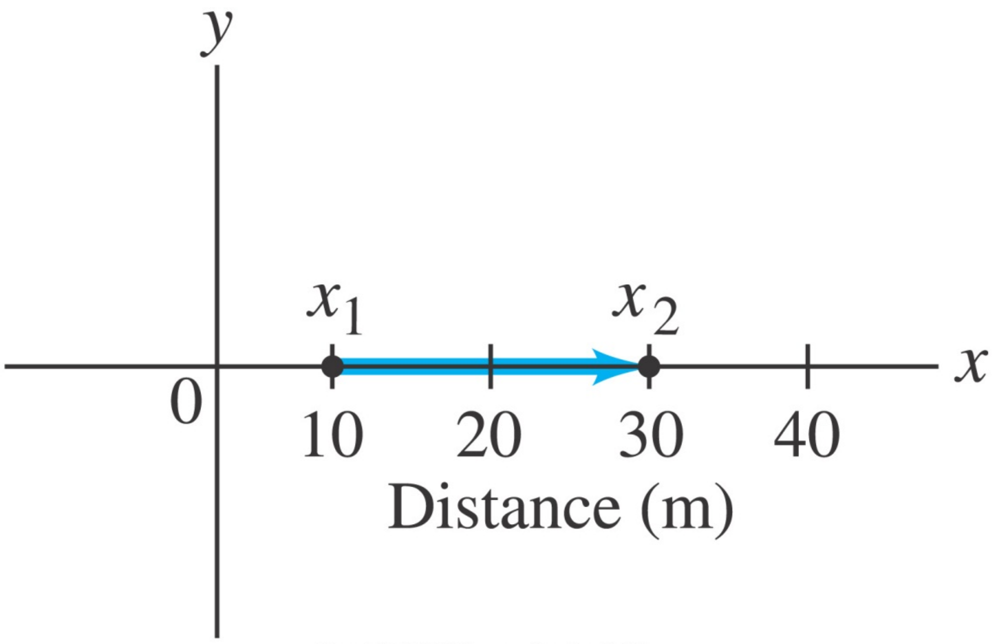


2-1 Reference Frames and Displacement

The displacement is written: $$\Delta x = x_2 - x_1$$

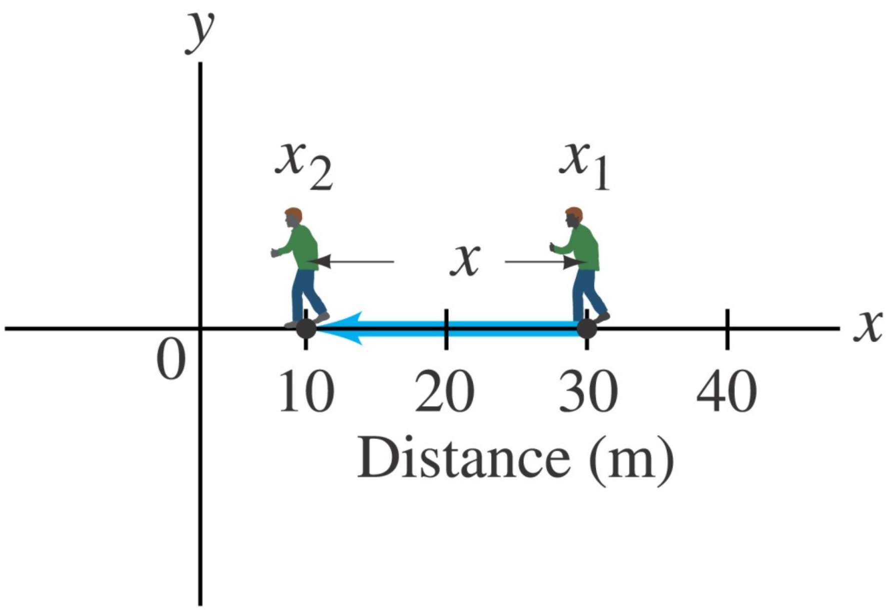
Left:

Displacement is positive.



Right:

Displacement is negative.



2-2 Average Velocity

Speed: how far an object travels in a given time interval

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time elapsed}} \tag{2-1}$$

Velocity includes directional information:

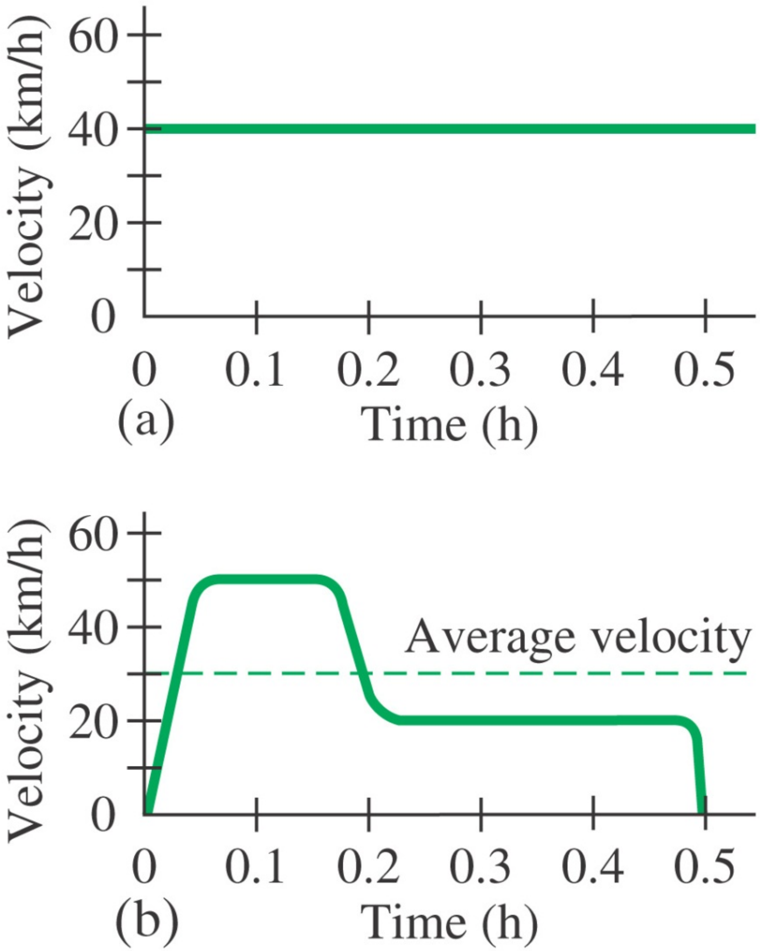
$$\text{average velocity} = \frac{\text{displacement}}{\text{time elapsed}}$$

2-3 Instantaneous Velocity

The instantaneous velocity is the average velocity, in the limit as the time interval becomes infinitesimally short.

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \qquad \textbf{(2-3)}$$

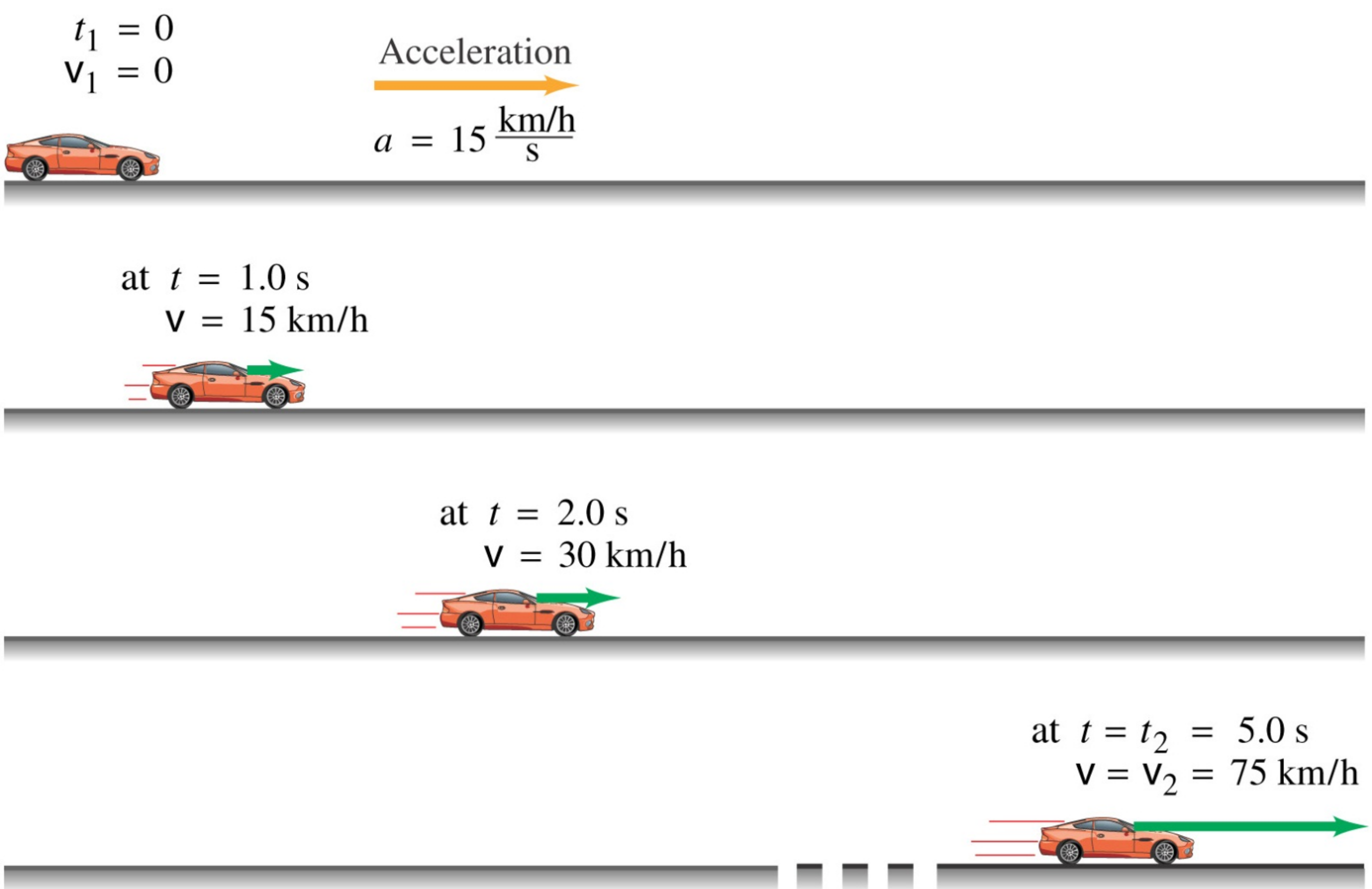
These graphs show (a) constant velocity and (b) varying velocity.



2-4 Acceleration

Acceleration is the rate of change of velocity.

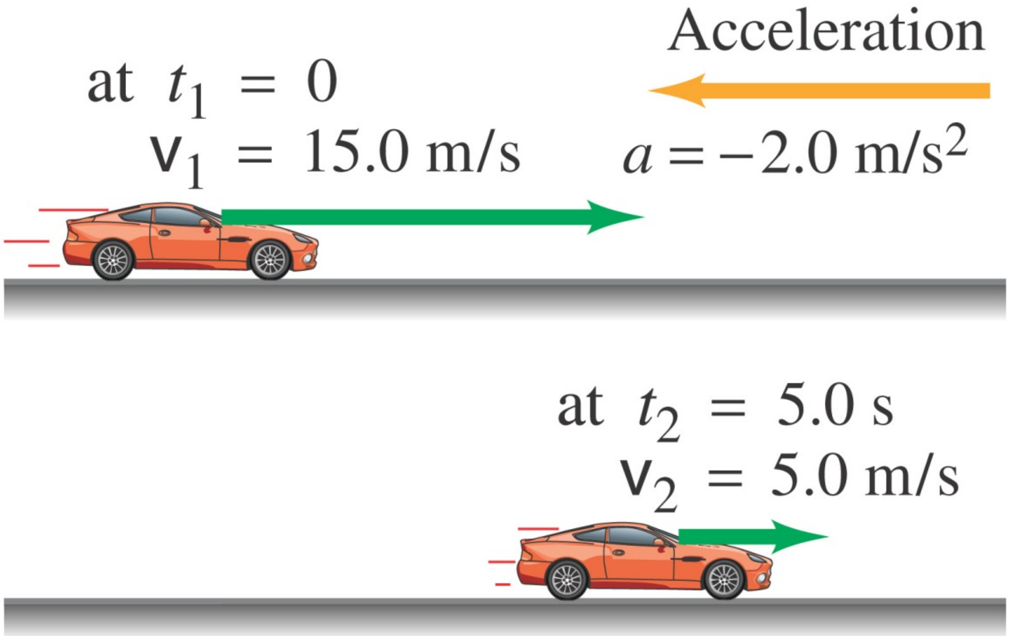
$$\text{average acceleration} = \frac{\text{change of velocity}}{\text{time elapsed}}$$



2-4 Acceleration

Acceleration is a vector, although in one-dimensional motion we only need the sign.

The previous image shows positive acceleration; here is negative acceleration:

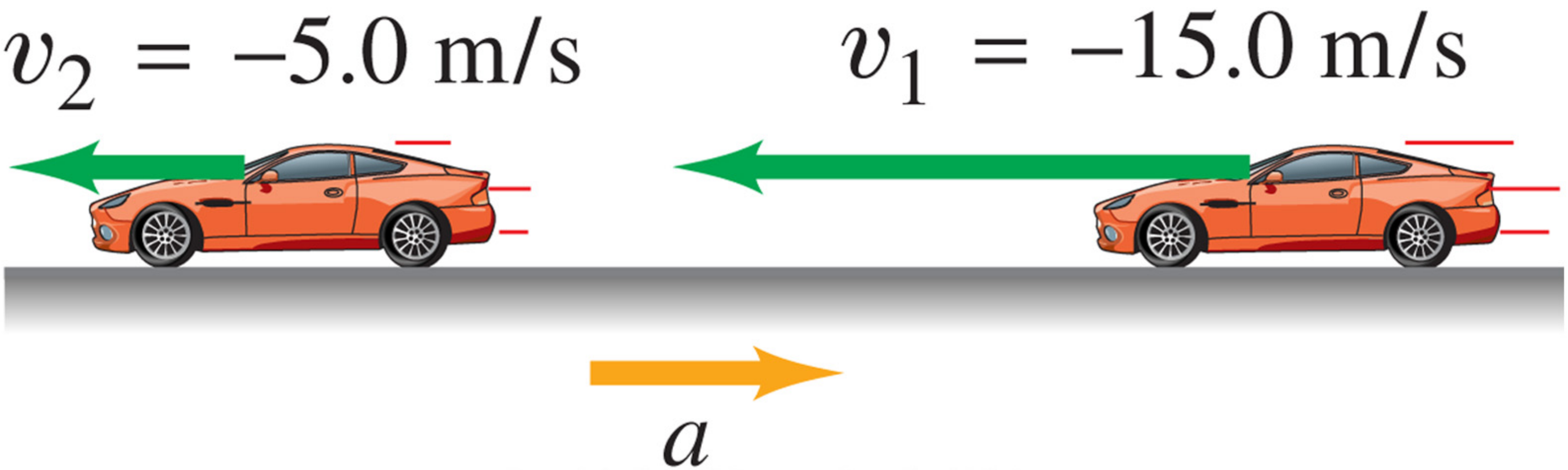


2-4 Acceleration

There is a difference between negative acceleration and deceleration:

Negative acceleration is acceleration in the negative direction as defined by the coordinate system.

Deceleration occurs when the acceleration is opposite in direction to the velocity.



2-4 Acceleration

The instantaneous acceleration is the average acceleration, in the limit as the time interval becomes infinitesimally short.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} \qquad \textbf{(2-5)}$$

2-5 Motion at Constant Acceleration

The average velocity of an object during a time interval *t* is

$$\bar{v} = \frac{x - x_0}{t - t_0} = \frac{x - x_0}{t}$$

The acceleration, assumed constant, is

$$a = \frac{v - v_0}{t}$$

2-5 Motion at Constant Acceleration

In addition, as the velocity is increasing at a constant rate, we know that

$$\bar{v} = \frac{v_0 + v}{2} \qquad \textbf{(2-8)}$$

Combining these last three equations, we find:

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2 \qquad \textbf{(2-9)}$$

2-5 Motion at Constant Acceleration

We can also combine these equations so as to eliminate *t*:

$$v^2 = v_0^2 + 2a(x - x_0) \quad \text{(2-10)}$$

We now have all the equations we need to solve constant-acceleration problems.

$$v = v_0 + at \quad \text{(2-11a)}$$

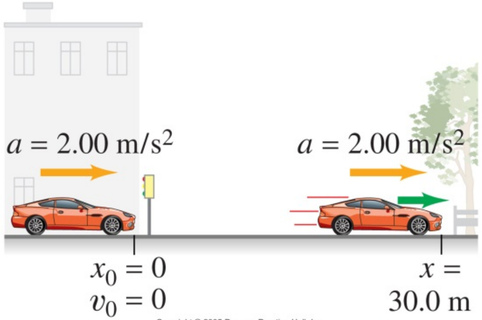
$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 \quad \text{(2-11b)}$$

$$v^2 = v_0^2 + 2a(x - x_0) \quad \text{(2-11c)}$$

$$\bar{v} = \frac{v + v_0}{2}. \quad \text{(2-11d)}$$

2-6 Solving Problems

1. Read the whole problem and make sure you understand it. Then read it again.
2. Decide on the objects under study and what the time interval is.
3. Draw a diagram and choose coordinate axes.
4. Write down the known (given) quantities, and then the unknown ones that you need to find.
5. What physics applies here? Plan an approach to a solution.



2-6 Solving Problems

6. Which equations relate the known and unknown quantities? Are they valid in this situation? Solve algebraically for the unknown quantities, and check that your result is sensible (correct dimensions).

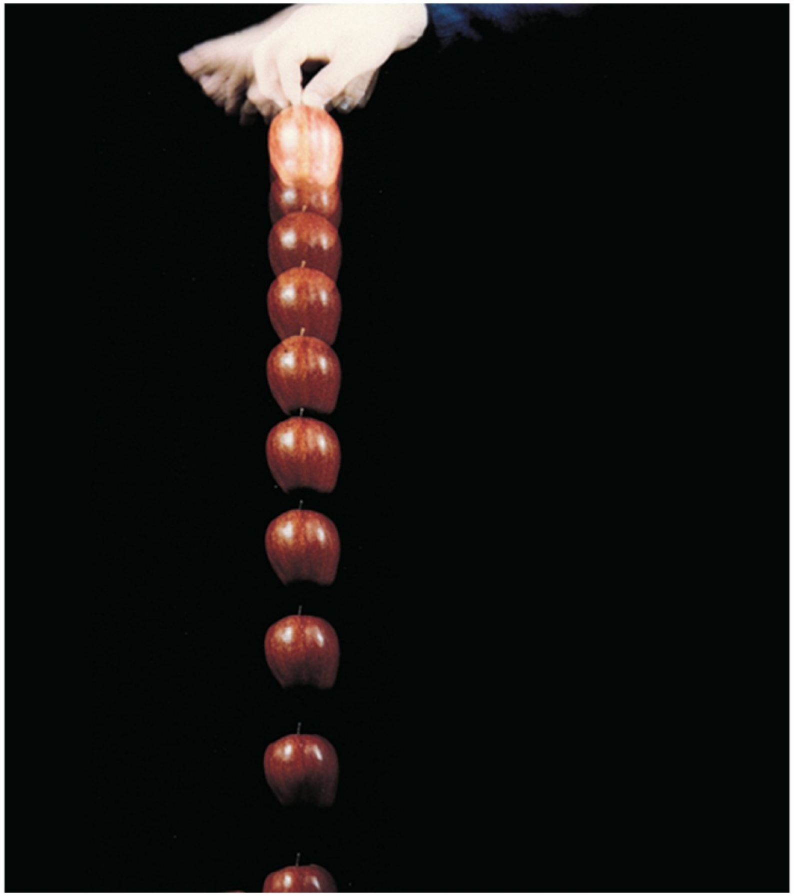
7. Calculate the solution and round it to the appropriate number of significant figures.

8. Look at the result – is it reasonable? Does it agree with a rough estimate?

9. Check the units again.

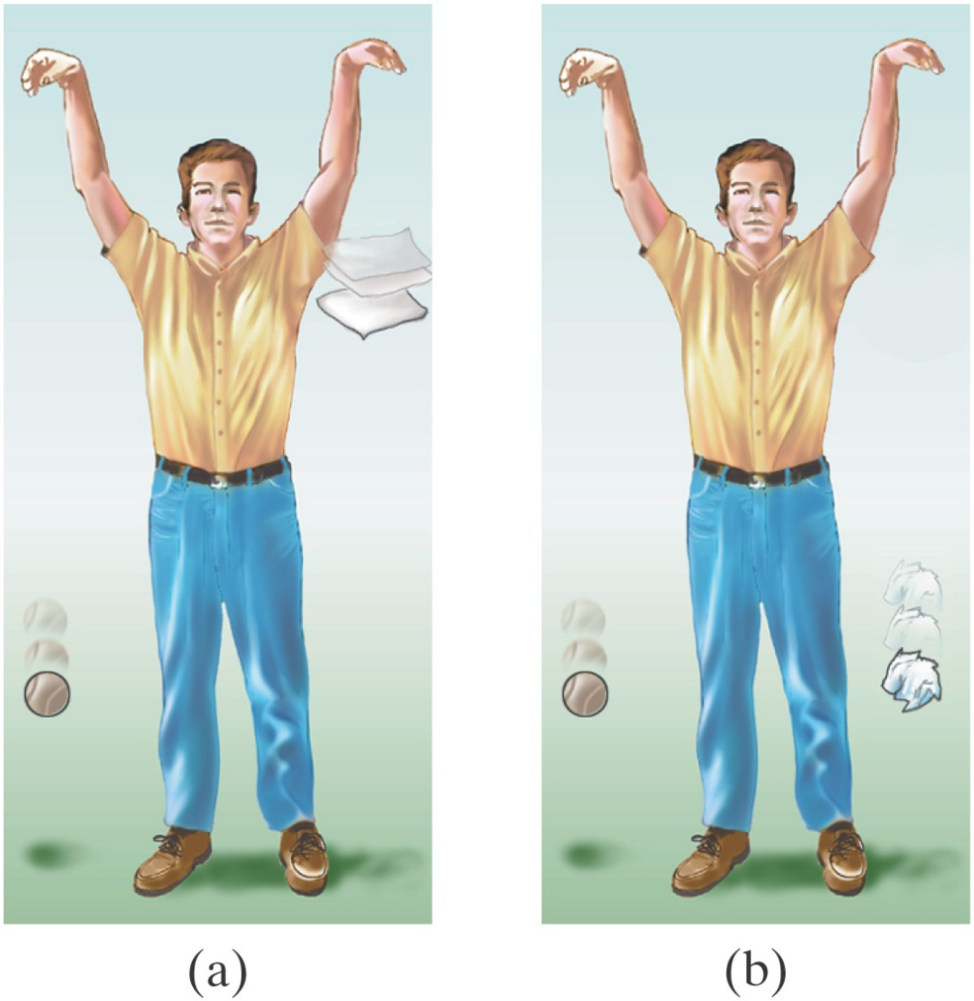
2-7 Falling Objects

Near the surface of the Earth, all objects experience approximately the same acceleration due to gravity.



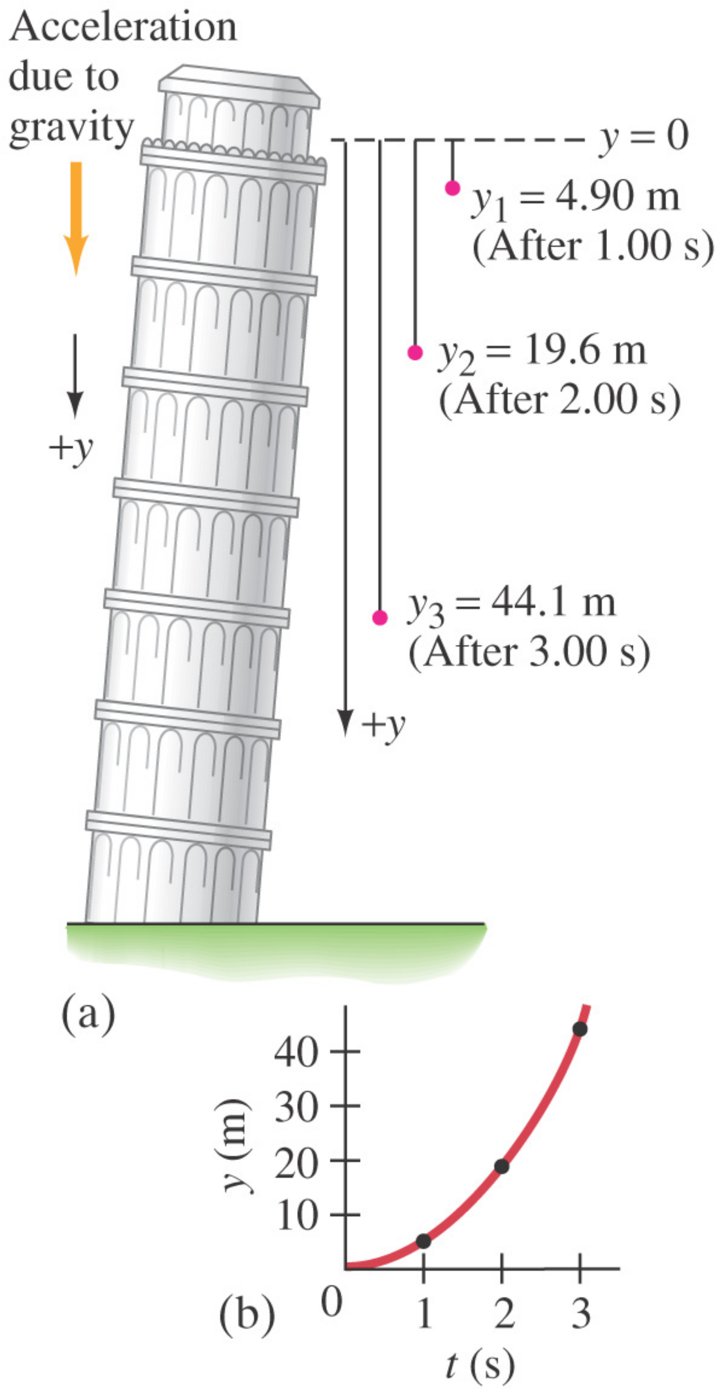
This is one of the most common examples of motion with constant acceleration.

2-7 Falling Objects



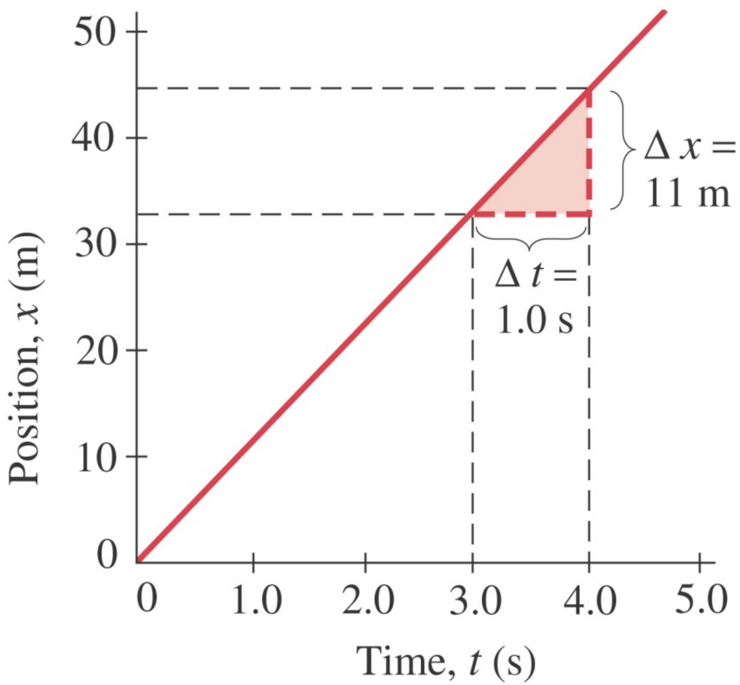
In the absence of air resistance, all objects fall with the same acceleration, although this may be hard to tell by testing in an environment where there is air resistance.

2-7 Falling Objects



The acceleration due to gravity at the Earth's surface is approximately 9.80 m/s^2.

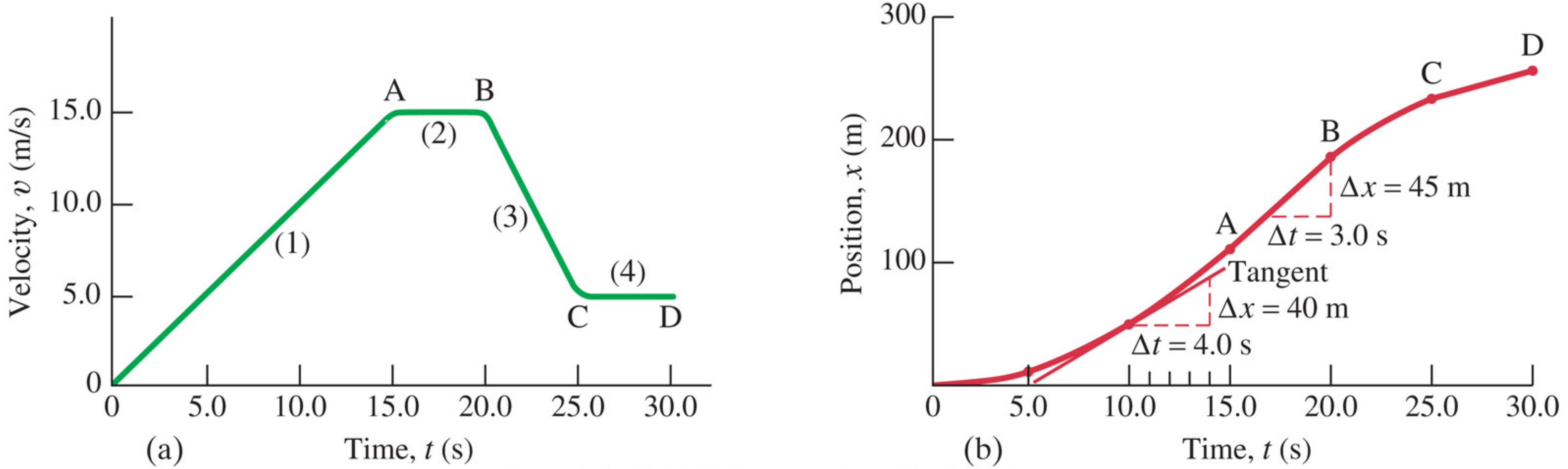
2-8 Graphical Analysis of Linear Motion



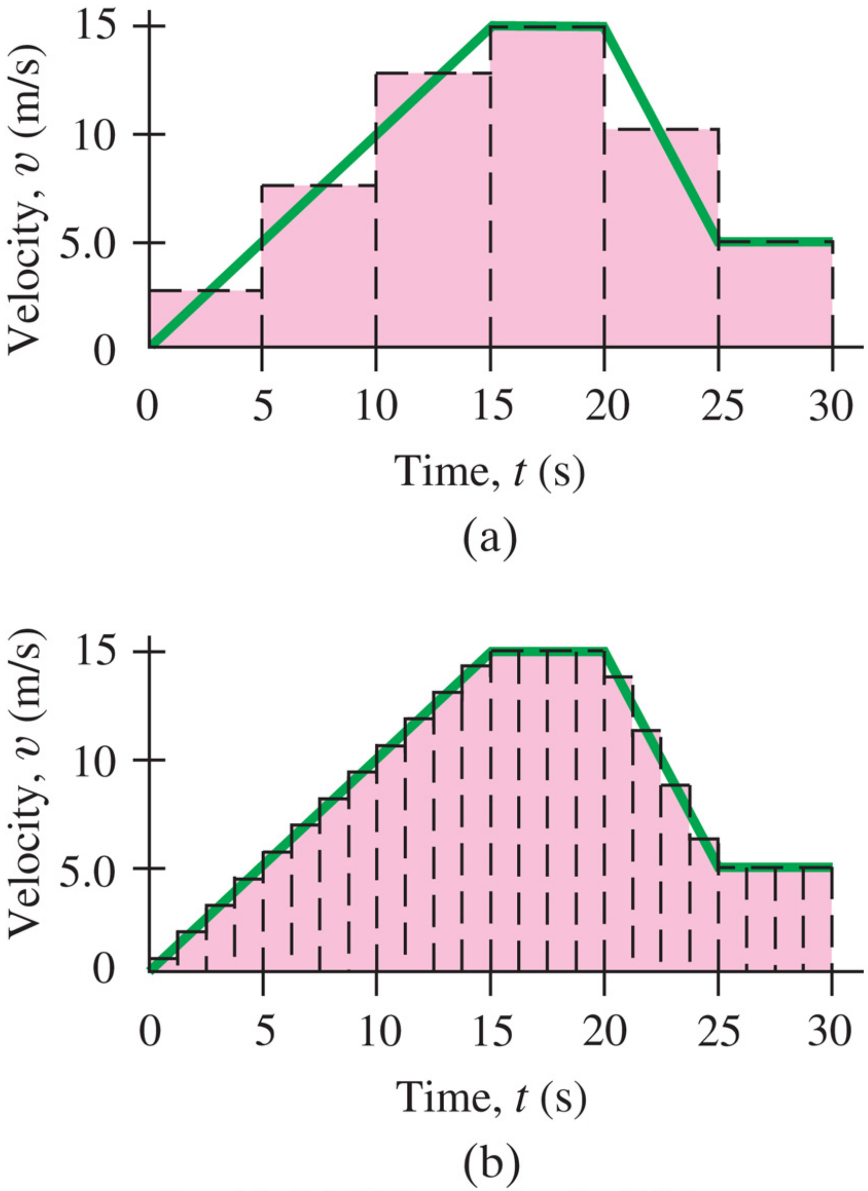
This is a graph of *x* vs. *t* for an object moving with constant velocity. The velocity is the slope of the *x-t* curve.

2-8 Graphical Analysis of Linear Motion

On the left we have a graph of velocity vs. time for an object with varying velocity; on the right we have the resulting *x* vs. *t* curve. The instantaneous velocity is tangent to the curve at each point.



2-8 Graphical Analysis of Linear Motion



The displacement, *x*, is the area beneath the *v* vs. *t* curve.

Summary of Chapter 2

- Kinematics is the description of how objects move with respect to a defined reference frame.

- Displacement is the change in position of an object.

- Average speed is the distance traveled divided by the time it took; average velocity is the displacement divided by the time.

- Instantaneous velocity is the limit as the time becomes infinitesimally short.

Summary of Chapter 2

- Average acceleration is the change in velocity divided by the time.
- Instantaneous acceleration is the limit as the time interval becomes infinitesimally small.
- The equations of motion for constant acceleration are given in the text; there are four, each one of which requires a different set of quantities.
- Objects falling (or having been projected) near the surface of the Earth experience a gravitational acceleration of 9.80 m/s^2.