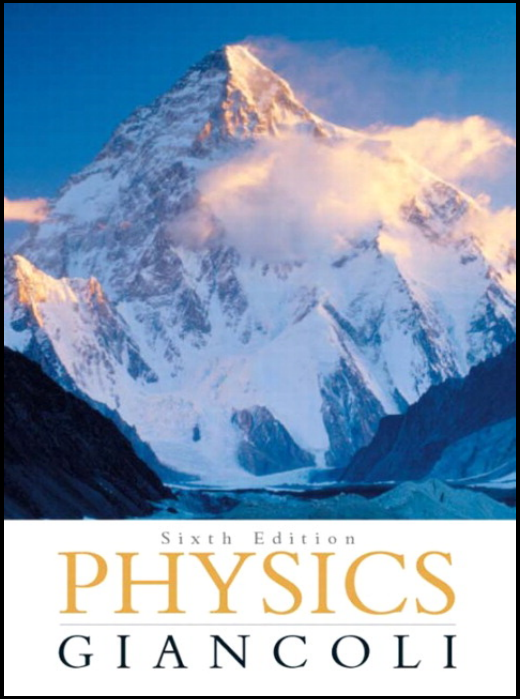


Lecture PowerPoints

Chapter 1

Physics: Principles with Applications, 6th edition

Giancoli

Chapter 1

Introduction, Measurement, Estimating

Units of Chapter 1

- **The Nature of Science**
- **Physics and Its Relation to Other Fields**
- **Models, Theories, and Laws**
- **Measurement and Uncertainty; Significant Figures**
- **Units, Standards, and the SI System**
- **Converting Units**
- **Order of Magnitude: Rapid Estimating**
- **Dimensions and Dimensional Analysis**

1-1 The Nature of Science

Observation: important first step toward scientific theory; requires imagination to tell what is important.

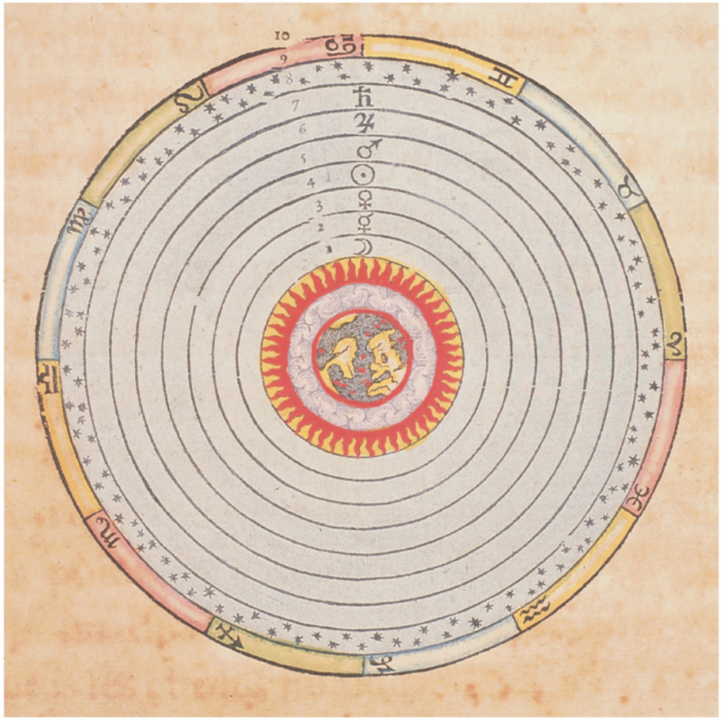
Theories: created to explain observations; will make predictions.

Observations will tell if the prediction is accurate, and the cycle goes on.

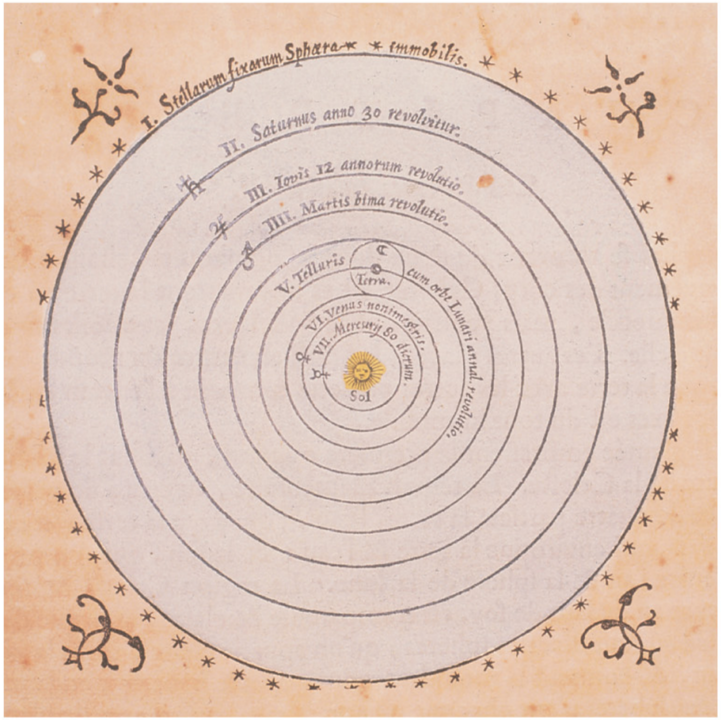
1-1 The Nature of Science

How does a **new theory** get accepted?

- **Predictions** agree better with data
- **Explains** a greater range of phenomena



(a)



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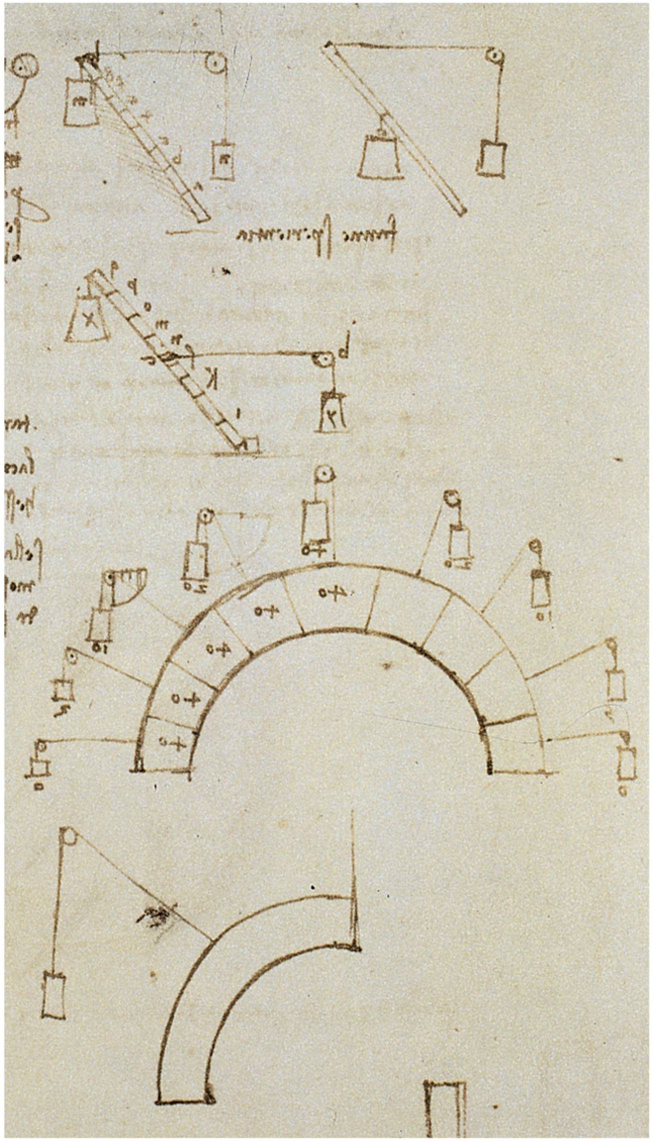
1-2 Physics and Its Relation to Other Fields



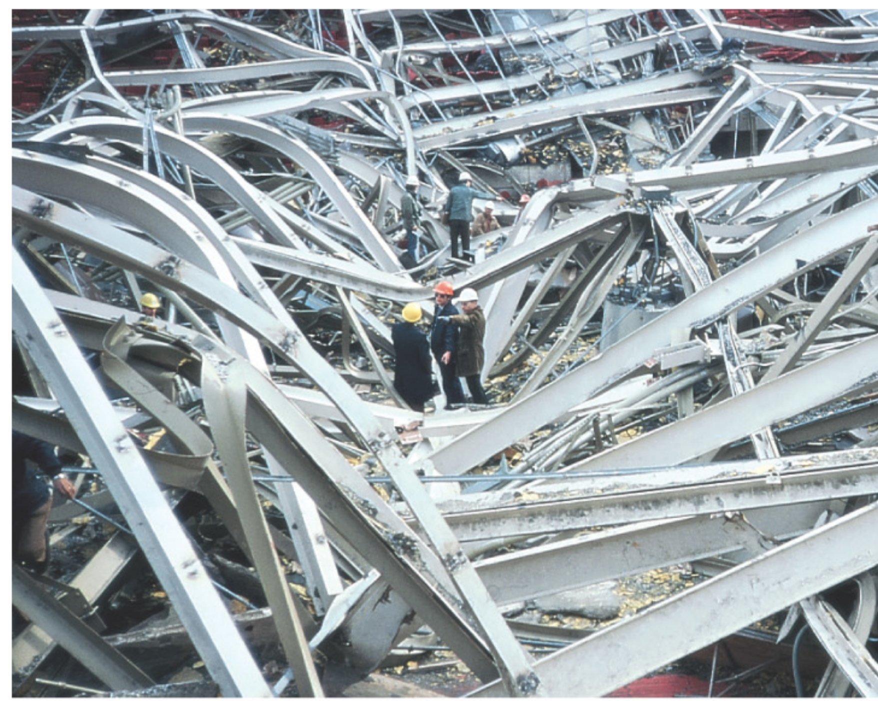
Physics is needed in both architecture and engineering.

Other fields that use physics, and make contributions to it: physiology, zoology, life sciences, …

1-2 Physics and Its Relation to Other Fields

Communication between architects and engineers is essential if disaster is to be avoided.

(a)



(b)

1-3 Models, Theories, and Laws

Models are very useful during the process of understanding phenomena. A model creates **mental pictures**; care must be taken to understand the **limits** of the model and not take it too seriously.

A **theory** is **detailed** and can give testable **predictions**.

A **law** is a brief description of how nature behaves in a broad set of circumstances.

A **principle** is similar to a law, but applies to a narrower range of phenomena.

1-4 Measurement and Uncertainty; Significant Figures

No measurement is exact; there is always some **uncertainty** due to limited instrument accuracy and difficulty reading results.

The photograph to the left illustrates this – it would be difficult to measure the width of this 2x4 to better than a **millimeter**.

1-4 Measurement and Uncertainty; Significant Figures

Estimated uncertainty is written with a ± sign; for example: $8.8 \pm 0.1\ \mathrm{cm}$

Percent uncertainty is the ratio of the uncertainty to the measured value, multiplied by 100:

$$\frac{0.1}{8.8} \times 100\% \approx 1\%$$

1-4 Measurement and Uncertainty; Significant Figures

The number of significant figures is the number of reliably known digits in a number. It is usually possible to tell the number of significant figures by the way the number is written:

23.21 cm has 4 significant figures

0.062 cm has 2 significant figures (the initial zeroes don't count)

80 km is ambiguous – it could have 1 or 2 significant figures. If it has 3, it should be written 80.0 km.

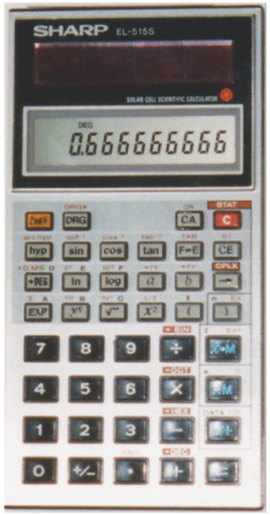
1-4 Measurement and Uncertainty; Significant Figures

When **multiplying** or **dividing** numbers, the result has as many significant figures as the number used in the calculation with the fewest significant figures.

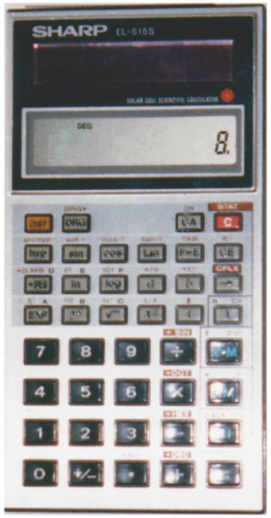
Example: 11.3 cm x 6.8 cm = 77 cm

When **adding** or **subtracting**, the answer is no more accurate than the least accurate number used.

1-4 Measurement and Uncertainty; Significant Figures



(a)



(b)

Calculators will not give you the right number of significant figures; they usually give too **many** but sometimes give too **few** (especially if there are trailing zeroes after a decimal point).

The top calculator shows the result of 2.0 / 3.0.

The bottom calculator shows the result of 2.5 x 3.2.

1-5 Units, Standards, and the SI System

Quantity	Unit	Standard
Length	Meter	Length of the path traveled by light in 1/299,792,458 second.
Time	Second	Time required for 9,192,631,770 periods of radiation emitted by cesium atoms
Mass	Kilogram	Platinum cylinder in International Bureau of Weights and Measures, Paris

1-5 Units, Standards, and the SI System

TABLE 1–4
Metric (SI) Prefixes

Prefix	Abbreviation	Value
yotta	Y	10^{24}
zetta	Z	10^{21}
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro†	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}

† μ is the Greek letter "mu."

These are the standard SI **prefixes** for indicating powers of 10. Many are familiar; Y, Z, E, h, da, a, z, and y are rarely used.

1-5 Units, Standards, and the SI System

We will be working in the SI system, where the basic units are **kilograms**, **meters**, and **seconds**.

TABLE 1–5 SI Base Quantities and Units

Quantity	Unit	Unit Abbre-viation
Length	meter	m
Time	second	s
Mass	kilogram	kg
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Other systems: **cgs**; units are grams, centimeters, and seconds.

British engineering system has force instead of mass as one of its basic quantities, which are feet, pounds, and seconds.

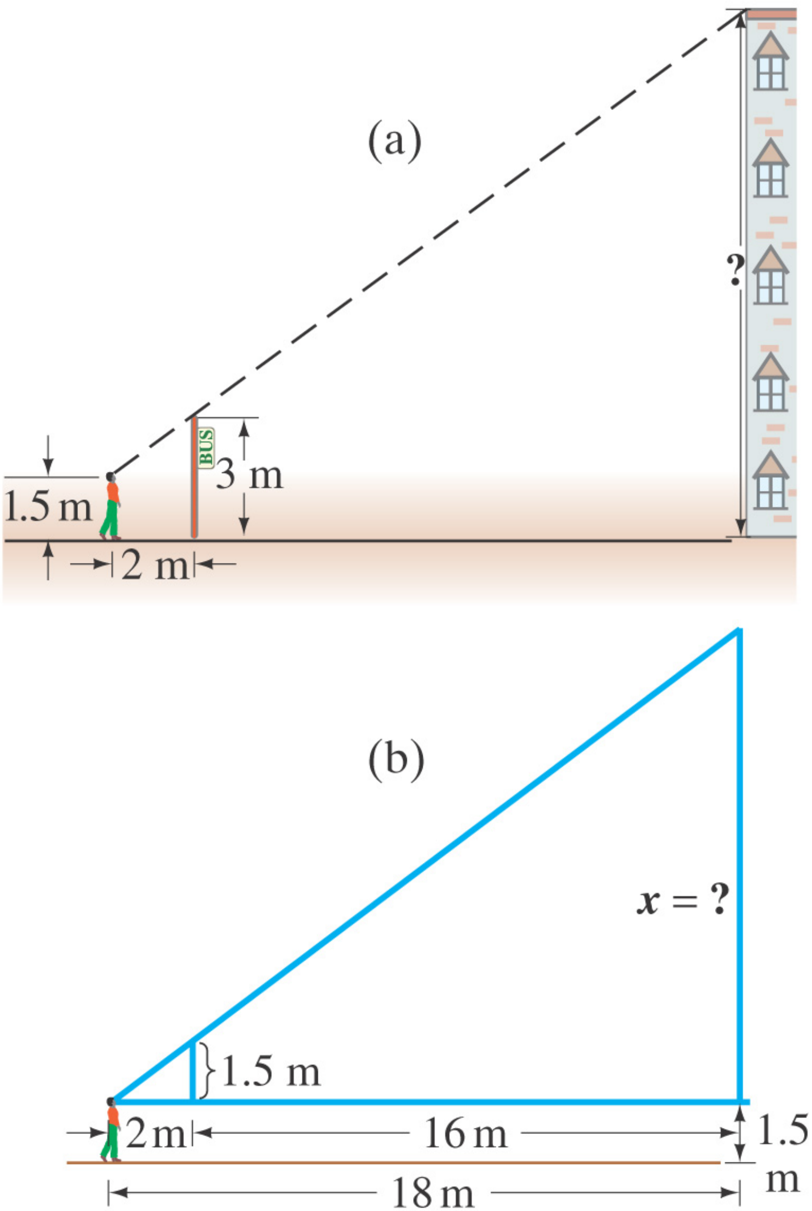
1-6 Converting Units

Converting between metric units, for example from kg to g, is easy, as all it involves is powers of **10**.

Converting to and from British units is considerably more work.

For example, given that 1 m = 3.28084 ft, this 8611-m mountain is 28251 feet high.

1-7 Order of Magnitude: Rapid Estimating



A quick way to **estimate** a calculated quantity is to round off all numbers to **one** significant figure and then calculate. Your result should at least be the right **order of magnitude**; this can be expressed by rounding it off to the nearest power of 10.

Diagrams are also very useful in making estimations.

1-8 Dimensions and Dimensional Analysis

Dimensions of a quantity are the **base units** that make it up; they are generally written using square brackets.

Example: Speed = distance / time

Dimensions of speed: [L/T]

Quantities that are being **added** or **subtracted** must have the same dimensions. In addition, a quantity calculated as the **solution** to a problem should have the correct dimensions.

Summary of Chapter 1

- Theories are created to explain observations, and then tested based on their predictions.

- A model is like an analogy; it is not intended to be a true picture, but just to provide a familiar way of envisioning a quantity.

- A theory is much more well-developed, and can make testable predictions; a law is a theory that can be explained simply, and which is widely applicable.

- Dimensional analysis is useful for checking calculations.

Summary of Chapter 1

- Measurements can never be exact; there is always some uncertainty. It is important to write them, as well as other quantities, with the correct number of significant figures.

- The most common system of units in the world is the SI system.

- When converting units, check dimensions to see that the conversion has been done properly.

- Order-of-magnitude estimates can be very helpful.

CHAPTER 1: Introduction, Measurement, Estimating

Questions

1. What are the merits and drawbacks of using a person's foot as a standard? Consider both (*a*) a particular person's foot, and (*b*) any person's foot. Keep in mind that it is advantageous that fundamental standards be accessible (easy to compare to), invariable (do not change), indestructible, and reproducible.

3. Why is it incorrect to think that the more digits you represent in your answer, the more accurate it is?

5. For an answer to be complete, the units need to be specified. Why?

7. You measure the radius of a wheel to be 4.16 cm. If you multiply by 2 to get the diameter, should you write the result as 8 cm or as 8.32 cm? Justify your answer.

9. A recipe for a soufflé specifies that the measured ingredients must be exact, or the soufflé will not rise. The recipe calls for 6 large eggs. The size of "large" eggs can vary by 10%, according to the USDA specifications. What does this tell you about how exactly you need to measure the other ingredients?

Problems

Measurement, Uncertainty, Significant Figures

(*Note:* In Problems, assume a number like 6.4 is accurate to ± 0.1; and 950 is ± 10 unless 950 is said to be "precisely" or "very nearly" 950, in which case assume $950 \pm 1.$)

1. (I) The age of the universe is thought to be about 14 billion years. Assuming two significant figures, write this in powers of ten in (*a*) years, (*b*) seconds.

3. (I) Write the following numbers in powers of ten notation: (*a*) 1.156, (*b*) 21.8, (*c*) 0.0068, (*d*) 27.635, (*e*) 0.219, and (*f*) 444.

5. (II) What, approximately, is the percent uncertainty for the measurement given as $1.57\ \mathrm{m}^2$?

7. (II) Time intervals measured with a stopwatch typically have an uncertainty of about 0.2 s, due to human reaction time at the start and stop moments. What is the percent uncertainty of a handtimed measurement of (*a*) 5 s, (*b*) 50 s, (*c*) 5 min?

9. (II) Multiply $2.079\times10^2\ \mathrm{m}$ by 0.082×10^{-1}, taking into account significant figures.

11. (III) What, roughly, is the percent uncertainty in the volume of a spherical beach ball whose radius is $r = 2.86 \pm 0.09\ \mathrm{m}$?

Units, Standards, SI, Converting Units

13. (I) Express the following using the prefixes of Table 1–4: (*a*) 1×10^6 volts, (*b*) 2×10^{-6} meters, (*c*) 6×10^3 days, (*d*) 18×10^2 bucks, and (*e*) 8×10^{-9} pieces.

15. (I) The Sun, on average, is 93 million miles from Earth. How many meters is this? Express (*a*) using powers of ten, and (*b*) using a metric prefix.

17. (II) An airplane travels at $950\ \mathrm{km/h}$. How long does it take to travel 1.00 km?

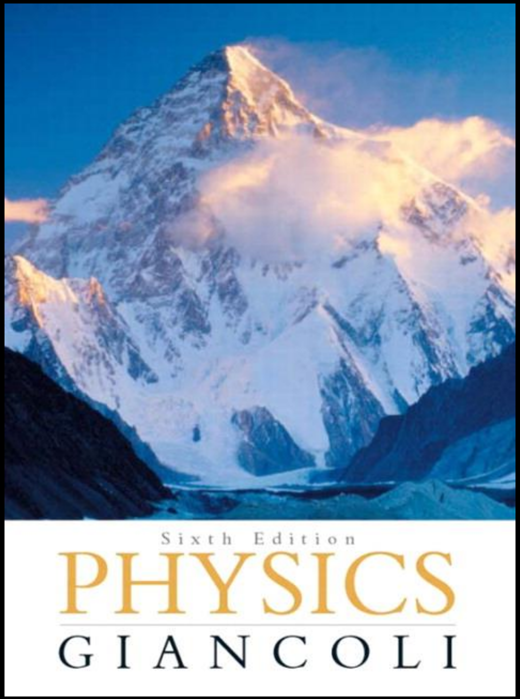
21. (II) How much longer (percentage) is a one-mile race than a 1500-m race (“the metric mile”)?

23. (III) The diameter of the Moon is 3480 km. (*a*) What is the surface area of the Moon? (*b*) How many times larger is the surface area of the Earth?

25. (II) Estimate how many books can be shelved in a college library with 3500 square meters of floor space. Assume 8 shelves high, having books on both sides, with corridors 1.5 m wide. Assume books are about the size of this one, on average.

27. (II) Estimate how long it would take one person to mow a football field using an ordinary home lawn mower (Fig. 1–13). Assume the mower moves with a $1\ \mathrm{km/h}$ speed, and has a 0.5 m width.

31. (III) The rubber worn from tires mostly enters the atmosphere as particulate pollution. Estimate how much rubber (in kg) is put into the air in the United States every year. To get started, a good estimate for a tire tread’s depth is 1 cm when new, and the density of rubber is about $1200\ \mathrm{kg/m^3}$.



Lecture PowerPoints

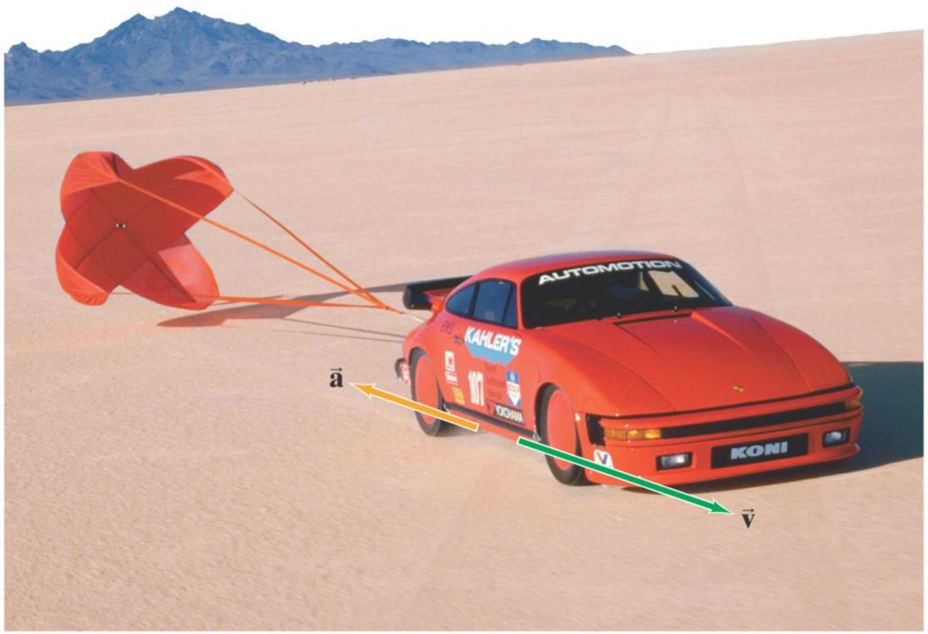
Chapter 2

Physics: Principles with Applications, 6th edition

Giancoli

Chapter 2

Describing Motion: Kinematics in One Dimension



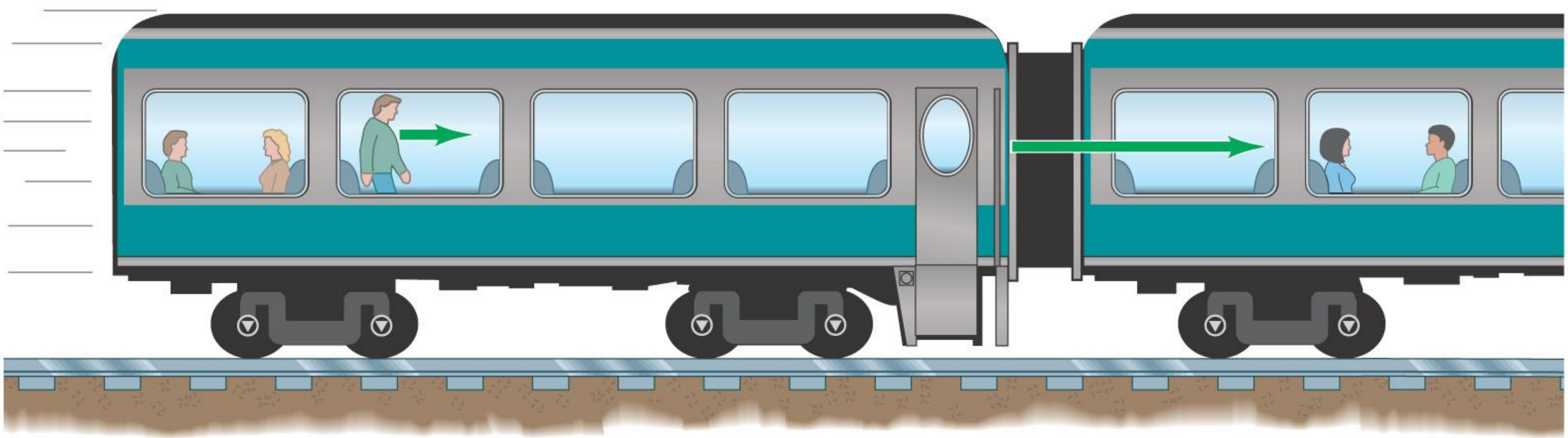
Units of Chapter 2

- 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.

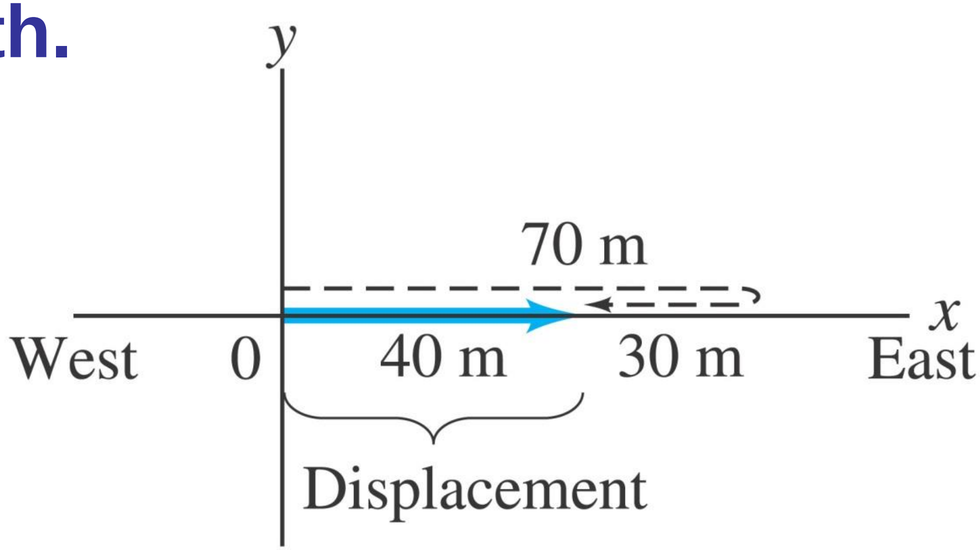


2-1 Reference Frames and Displacement

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

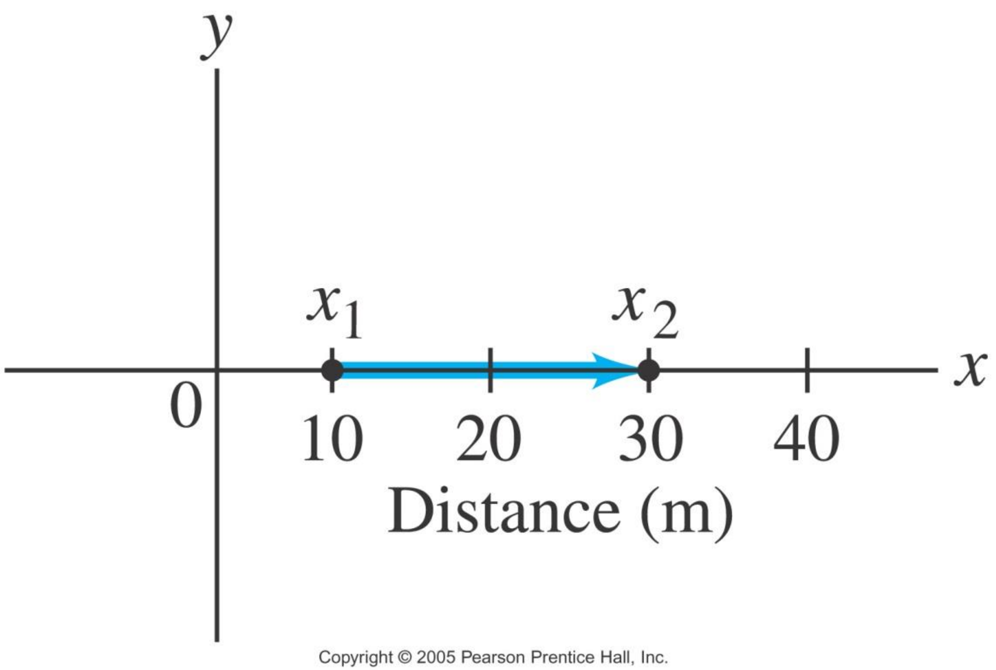
The displacement is written: $\Delta x = x_2 - x_1$

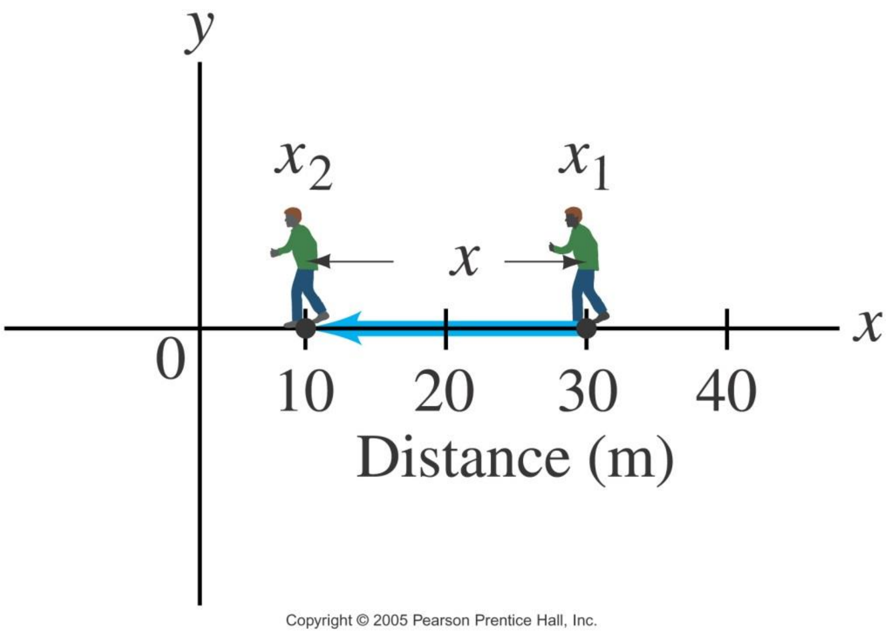
Left:

Displacement is positive.

Right:

Displacement is negative.





2-2 Average Velocity

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

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time elapsed}} \qquad \textbf{(2-1)}$$

Velocity includes directional information:

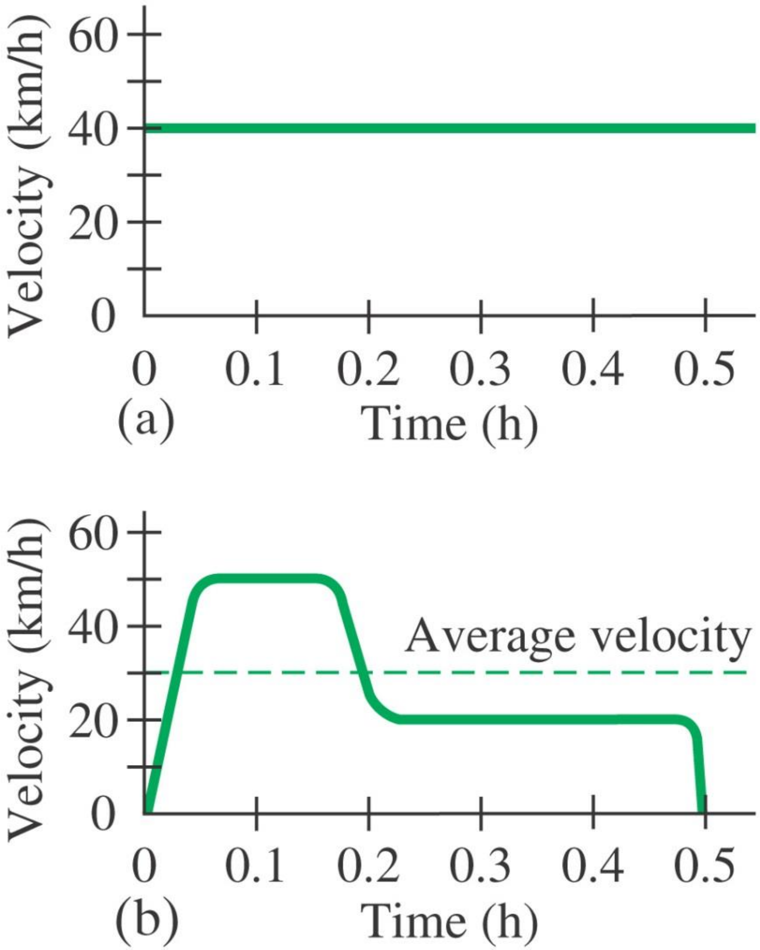
$$\text{average velocity} = \frac{\text{displacement}}{\text{time elapsed}}$$

2-3 Instantaneous Velocity

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

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

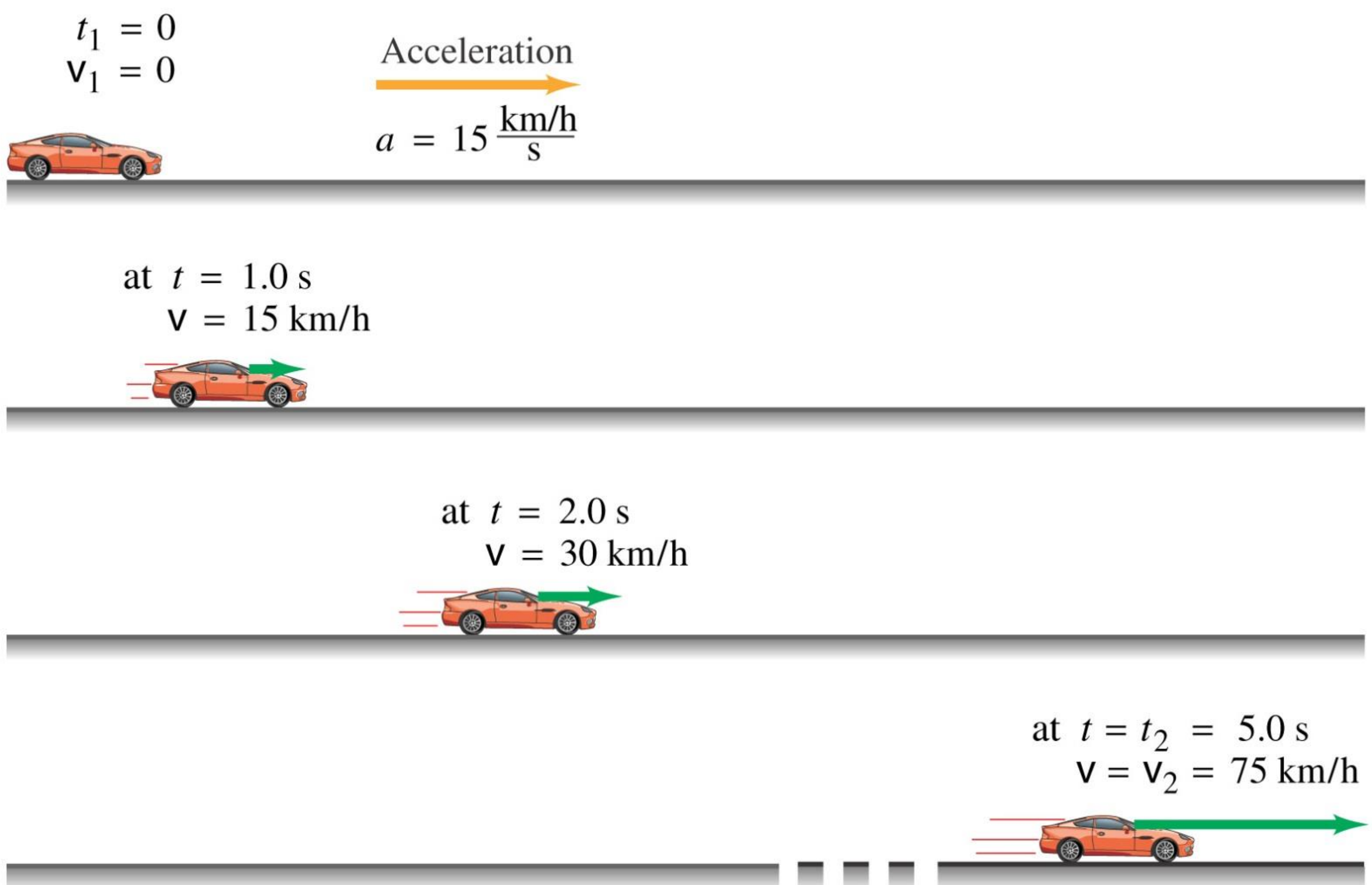
These graphs show (a) constant velocity and (b) varying velocity.



2-4 Acceleration

Acceleration is the rate of change of velocity.

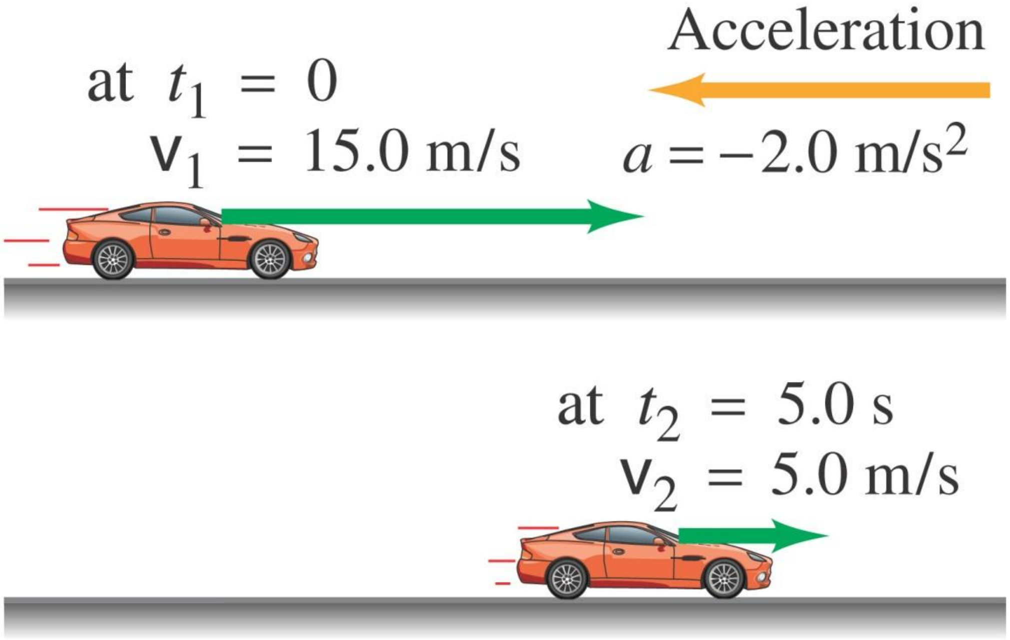
$$\text{average acceleration} = \frac{\text{change of velocity}}{\text{time elapsed}}$$



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:

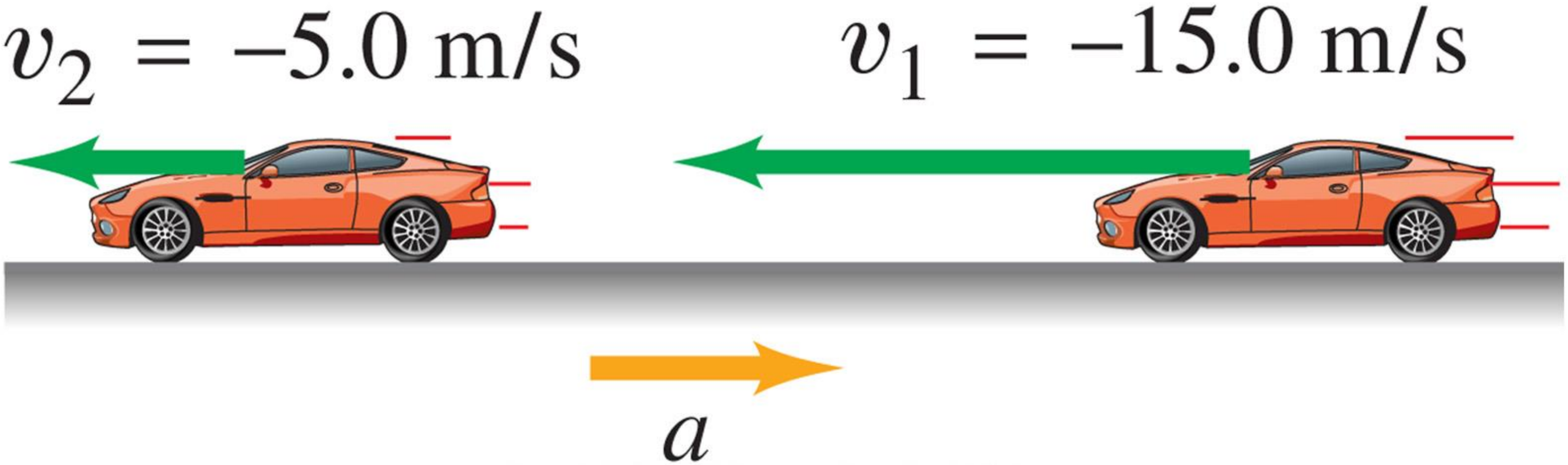


2-4 Acceleration

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

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

Combining these last three equations, we find:

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

2-5 Motion at Constant Acceleration

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

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

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

$$v = v_0 + at \qquad \textbf{(2-11a)}$$

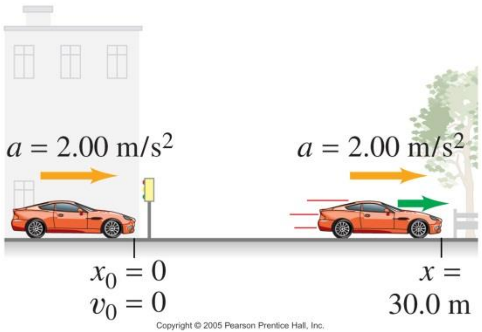
$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 \qquad \textbf{(2-11b)}$$

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

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

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).

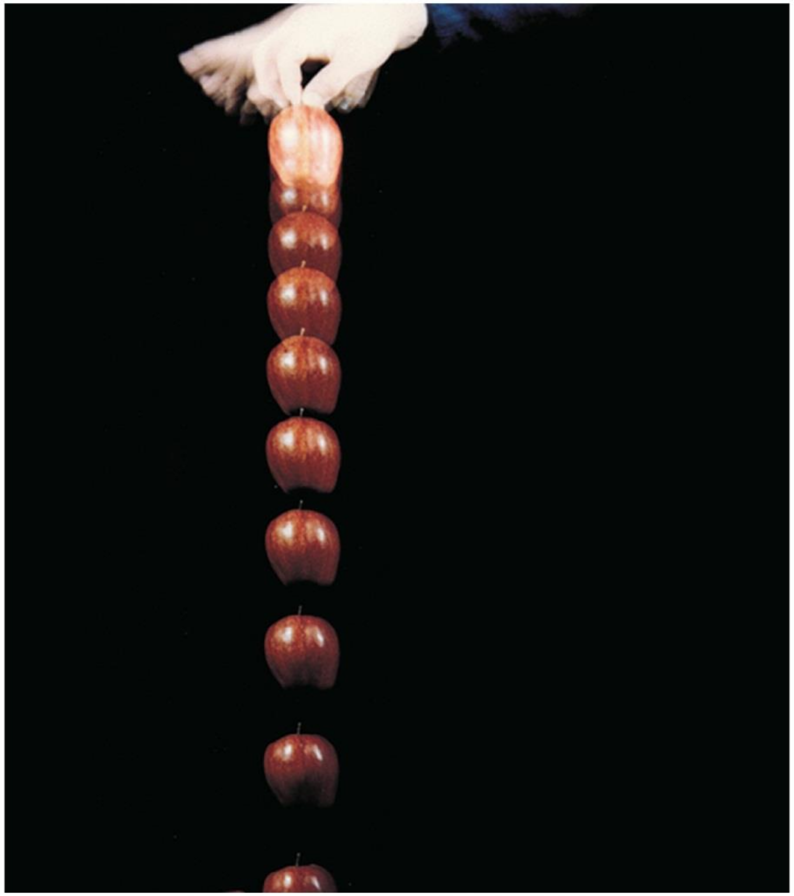
7. Calculate the solution and round it to the appropriate number of significant figures.

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.



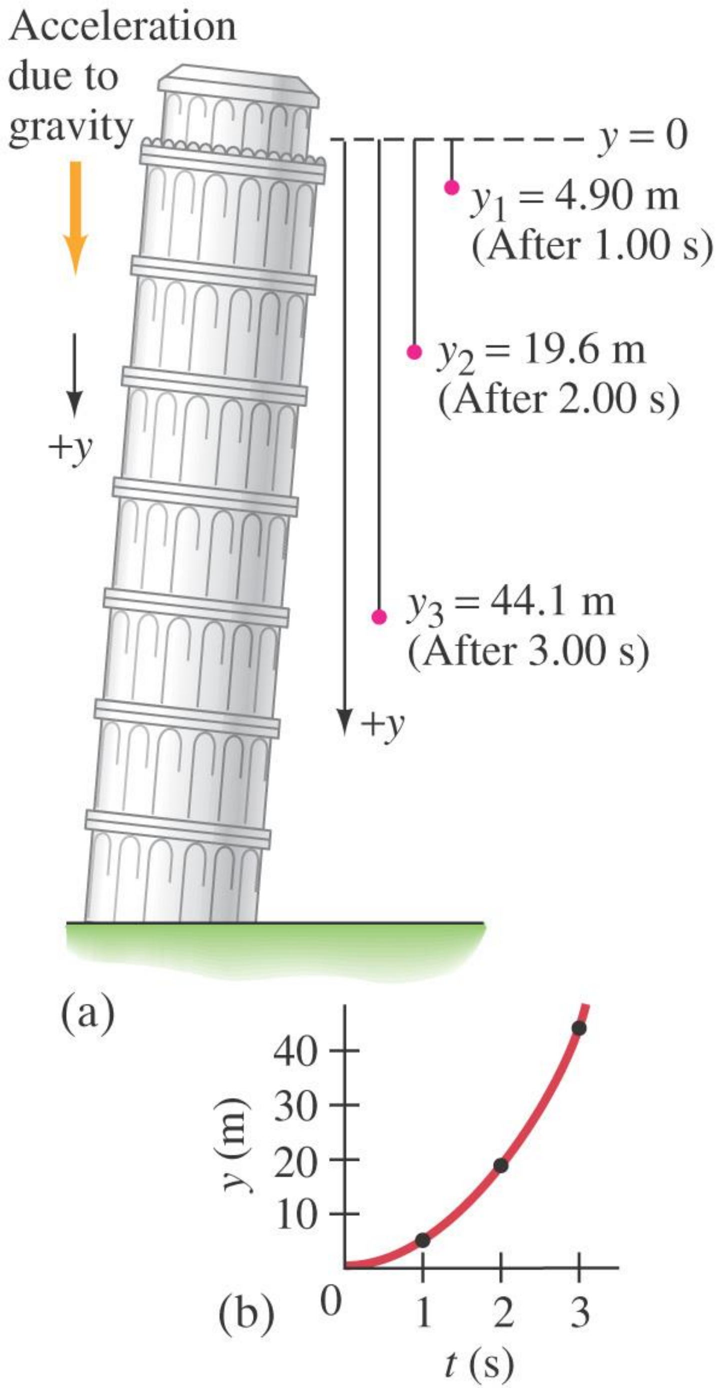
This is one of the most common examples of motion with constant acceleration.

2-7 Falling Objects


(a) (b)

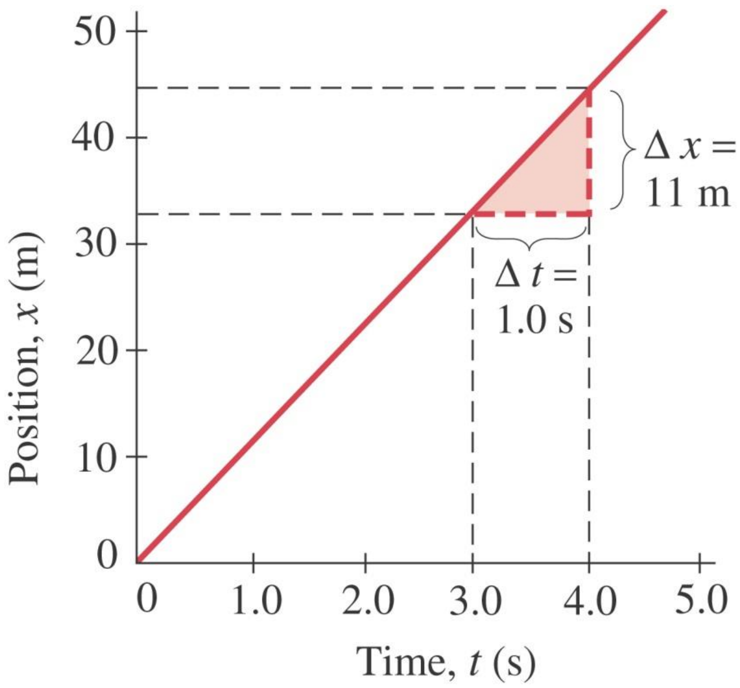
In the absence of air resistance, all objects fall with the same acceleration, although this may be hard to tell by testing in an environment where there is air resistance.

2-7 Falling Objects



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

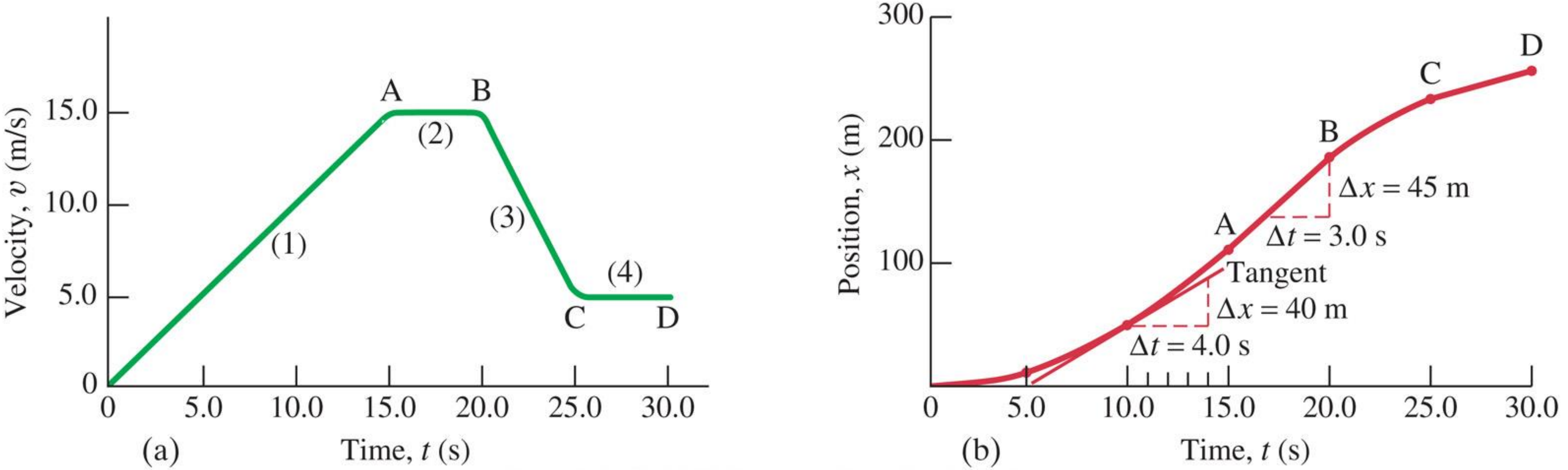
2-8 Graphical Analysis of Linear Motion



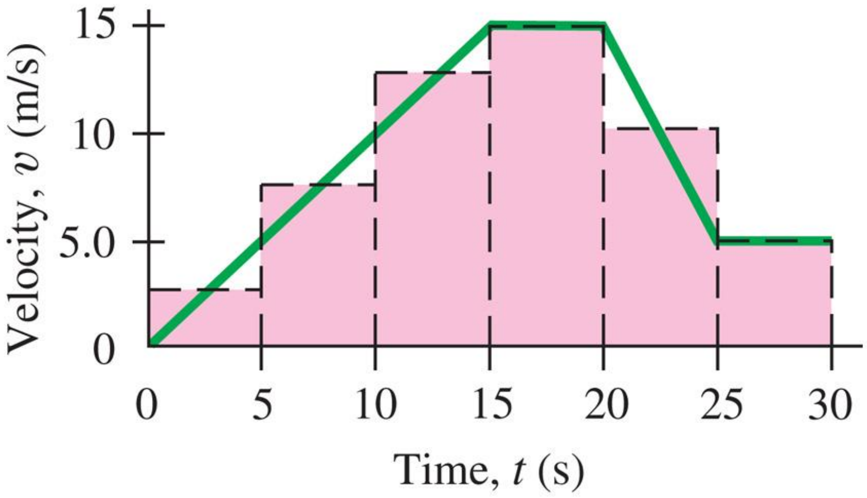
This is a graph of *x* vs. *t* for an object moving with constant velocity. The velocity is the slope of the *x*-*t* curve.

2-8 Graphical Analysis of Linear Motion

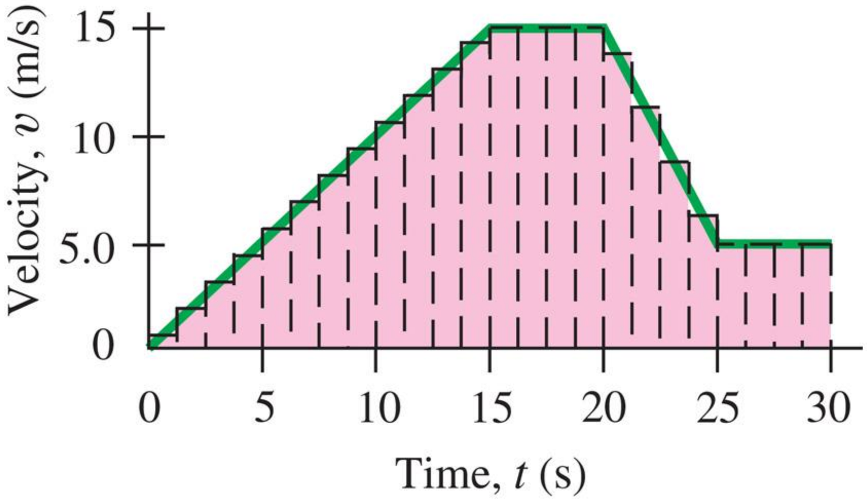
On the left we have a graph of velocity vs. time for an object with varying velocity; on the right we have the resulting *x* vs. *t* curve. The instantaneous velocity is tangent to the curve at each point.



2-8 Graphical Analysis of Linear Motion



(a)



(b)

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.

CHAPTER 2: Describing Motion: Kinematics in One Dimension

Questions

1. Does a car speedometer measure speed, velocity, or both?

3. When an object moves with constant velocity, does its average velocity during any time interval differ from its instantaneous velocity at any instant?

5. If one object has a greater speed than a second object, does the first necessarily have a greater acceleration? Explain, using examples.

7. Can an object have a northward velocity and a southward acceleration? Explain.

9. Give an example where both the velocity and acceleration are negative.

11. Can an object be increasing in speed as its acceleration decreases? If so, give an example. If not, explain.

13. As a freely falling object speeds up, what is happening to its acceleration due to gravity — does it increase, decrease, or stay the same?

15. You travel from point A to point B in a car moving at a constant speed of $70\,\text{km/h}$. Then you travel the same distance from point B to another point C, moving at a constant speed of $90\,\text{km/h}$. Is your average speed for the entire trip from A to C $80\,\text{km/h}$? Explain why or why not.

17. Which one of these motions is *not* at constant acceleration: a rock falling from a cliff, an elevator moving from the second floor to the fifth floor making stops along the way, a dish resting on a table?

19. Can an object have zero velocity and nonzero acceleration at the same time? Give examples.

Problems

[The Problems at the end of each Chapter are ranked I, II, or III according to estimated difficulty, with (I) Problems being easiest. Level III are meant as challenges for the best students. The Problems are arranged by Section, meaning that the reader should have read up to and including that Section, but not only that Section — Problems often depend on earlier material. Finally, there is a set of unranked "General Problems" not arranged by Section number.]

2–1 to 2–3 Speed and Velocity

1. (I) What must be your car's average speed in order to travel 235 km in 3.25 h?

3. (I) If you are driving $110\,\mathrm{km/h}$ along a straight road and you look to the side for 2.0 s, how far do you travel during this inattentive period?

5. (I) A rolling ball moves from $x_1 = 3.4\,\mathrm{cm}$ to $x_2 = -4.2\,\mathrm{cm}$ during the time from $t_1 = 3.0\,\mathrm{s}$ to $t_2 = 6.1\,\mathrm{s}$. What is its average velocity?

7. (II) You are driving home from school steadily at $95\,\mathrm{km/h}$ for 130 km. It then begins to rain and you slow to $65\,\mathrm{km/h}$. You arrive home after driving 3 hours and 20 minutes. (*a*) How far is your hometown from school? (*b*) What was your average speed?

9. (II) A person jogs eight complete laps around a quarter-mile track in a total time of 12.5 min. Calculate (*a*) the average speed and (*b*) the average velocity, in $\mathrm{m/s}$.

11. (II) Two locomotives approach each other on parallel tracks. Each has a speed of $95\,\mathrm{km/h}$ with respect to the ground. If they are initially 8.5 km apart, how long will it be before they reach each other? (See Fig. 2–30).

15. (III) A bowling ball traveling with constant speed hits the pins at the end of a bowling lane 16.5 m long. The bowler hears the sound of the ball hitting the pins 2.50 s after the ball is released from his hands. What is the speed of the ball? The speed of sound is $340\,\mathrm{m/s}$.

17. (I) A sprinter accelerates from rest to $10.0\,\mathrm{m/s}$ in 1.35 s. What is her acceleration (*a*) in $\mathrm{m/s^2}$, and (*b*) in $\mathrm{km/h^2}$?

19. (II) A sports car moving at constant speed travels 110 m in 5.0 s. If it then brakes and comes to a stop in 4.0 s, what is its acceleration in $\mathrm{m/s^2}$? Express the answer in terms of "*g*'s," where $1.00\,g = 9.80\,\mathrm{m/s^2}$.

2–5 and 2–6 Motion at Constant Acceleration

21. (I) A car accelerates from $13\,\mathrm{m/s}$ to $25\,\mathrm{m/s}$ in 6.0 s. What was its acceleration? How far did it travel in this time? Assume constant acceleration.

23. (I) A light plane must reach a speed of $33\,\mathrm{m/s}$ for takeoff. How long a runway is needed if the (constant) acceleration is $3.0\,\mathrm{m/s^2}$?

25. (II) A car slows down uniformly from a speed of $21.0\,\mathrm{m/s}$ to rest in 6.00 s. How far did it travel in that time?

27. (II) A car traveling $85\,\mathrm{km/h}$ strikes a tree. The front end of the car compresses and the driver comes to rest after traveling 0.80 m. What was the average acceleration of the driver during the collision? Express the answer in terms of "*g*'s," where $1.00\,g = 9.80\,\mathrm{m/s^2}$.

2–7 Falling Objects [neglect air resistance]

33. (I) A stone is dropped from the top of a cliff. It hits the ground below after 3.25 s. How high is the cliff?

35. (I) Estimate (*a*) how long it took King Kong to fall straight down from the top of the Empire State Building (380 m high), and (*b*) his velocity just before "landing"?

39. (II) A helicopter is ascending vertically with a speed of $5.20\,\mathrm{m/s}$. At a height of 125 m above the Earth, a package is dropped from a window. How much time does it take for the package to reach the ground? [*Hint*: The package's initial speed equals the helicopter's.]