Preview

- Objectives
- Physics
- The Scientific Method
- Models
- Hypotheses
- Controlled Experiments

Objectives

- **Identify** activities and fields that involve the major areas within physics.
- **Describe** the processes of the scientific method.
- **Describe** the role of models and diagrams in physics.

The Branches of Physics

Click below to watch the Visual Concept.

Visual Concept

The Branches of Physics

Name	Subjects	Examples
Mechanics	motion and its causes, interactions between objects	falling objects, friction, weight, spinning objects
Thermodynamics	heat and temperature	melting and freezing processes, engines, refrigerators
Vibrations and wave phenomena	specific types of repetitive motions	springs, pendulums, sound
Optics	light	mirrors, lenses, color, astronomy
Electromagnetism	electricity, magnetism, and light	electrical charge, circuitry, permanent magnets, electromagnets
Relativity	particles moving at any speed, including very high speeds	particle collisions, particle accelerators, nuclear energy
Quantum mechanics	behavior of submicroscopic particles	the atom and its parts

Physics

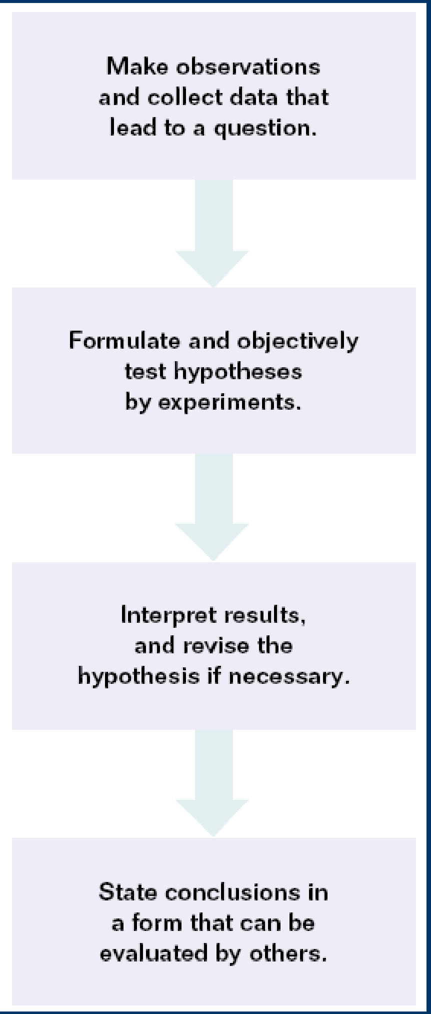
- The **goal of physics** is to use a small number of basic **concepts, equations,** and **assumptions** to describe the physical world.
- These physics principles can then be used to make **predictions** about a broad range of phenomena.
- Physics discoveries often turn out to have unexpected practical applications, and advances in technology can in turn lead to new physics discoveries.

Physics and Technology

The Scientific Method

- There is no single procedure that scientists follow in their work. However, there are certain steps common to all good scientific investigations.

- These steps are called the **scientific method.**



The Scientific Method

Click below to watch the Visual Concept.

Visual Concept

Models

- Physics uses **models** that describe phenomena.
- A **model** is a pattern, plan, representation, or description designed to show the structure or workings of an object, system, or concept.
- A set of particles or interacting components considered to be a distinct physical entity for the purpose of study is called a **system.**

End of Slide

Models

Click below to watch the Visual Concept.

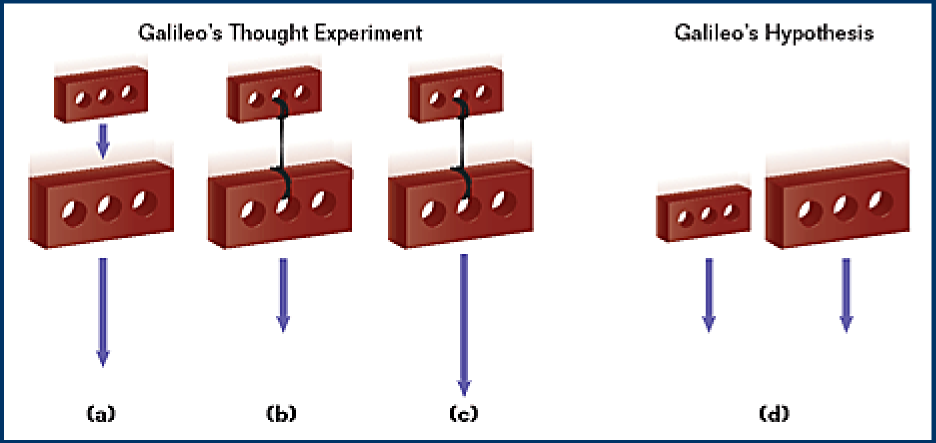
Visual Concept

Hypotheses

- Models help scientists develop **hypotheses.**
- A **hypothesis** is an explanation that is based on prior scientific research or observations and that can be tested.
- The process of simplifying and modeling a situation can help you determine the relevant variables and identify a hypothesis for testing.

Hypotheses, *continued*

Galileo modeled the behavior of falling objects in order to develop a hypothesis about how objects fall.



If heavier objects fell faster than slower ones,would two bricks of different masses tied together fall slower **(b)** or faster **(c)** than the heavy brick alone **(a)?** Because of this contradiction, Galileo hypothesized instead that all objects fall at the same rate, as in **(d).**

End Of Slide

Controlled Experiments

- A hypothesis must be tested in a **controlled experiment.**
- A controlled experiment tests only one factor at a time by using a comparison of a **control group** with an **experimental group.**

Controlled Experiments

Click below to watch the Visual Concept.

Visual Concept

Preview

- Objectives
- Numbers as Measurements
- Dimensions and Units
- Sample Problem
- Accuracy and Precision
- Significant Figures

Objectives

- **List** basic SI units and the quantities they describe.
- **Convert** measurements into scientific notation.
- **Distinguish** between accuracy and precision.
- **Use** significant figures in measurements and calculations.

Numbers as Measurements

- In **SI,** the standard measurement system for science, there are **seven base units.**
- Each base unit describes a **single dimension,** such as length, mass, or time.
- The units of **length, mass,** and **time** are the **meter (m), kilogram (kg),** and **second (s),** respectively.
- **Derived units** are formed by combining the seven base units with multiplication or division. For example, speeds are typically expressed in units of meters per second (m/s).

End of Slide

SI Standards

Unit	Original standard	Current standard
meter (length)	$\frac{1}{10\,000\,000}$ distance from equator to North Pole	the distance traveled by light in a vacuum in $3.33564095 \times 10^{-9}$ s
kilogram (mass)	mass of 0.001 cubic meters of water	the mass of a specific platinum-iridium alloy cylinder
second (time)	$\left(\frac{1}{60}\right)\left(\frac{1}{60}\right)\left(\frac{1}{24}\right) =$ 0.000 011 574 average solar days	9 192 631 770 times the period of a radio wave emitted from a cesium-133 atom

SI Prefixes

Power	Prefix	Abbreviation	Power	Prefix	Abbreviation
10^{-18}	atto-	a	10^{-1}	deci-	d
10^{-15}	femto-	f	10^{1}	deka-	da
10^{-12}	pico-	p	10^{3}	kilo-	k
10^{-9}	nano-	n	10^{6}	mega-	M
10^{-6}	micro-	µ (Greek letter *mu*)	10^{9}	giga-	G
			10^{12}	tera-	T
10^{-3}	milli-	m	10^{15}	peta-	P
10^{-2}	centi-	c	10^{18}	exa-	E

In SI, units are combined with **prefixes** that symbolize certain **powers of 10.** The most common prefixes and their symbols are shown in the table.

Dimensions and Units

- Measurements of physical quantities must be expressed in units that match the **dimensions** of that quantity.
- In addition to having the correct **dimension,** measurements used in calculations should also have the same **units.**

For example, when determining area by multiplying length and width, be sure the measurements are expressed in the same units.

Dimensions and Units

Click below to watch the Visual Concept.

Visual Concept

Sample Problem

A typical bacterium has a mass of about 2.0 fg. Express this measurement in terms of grams and kilograms.

Given:

mass = 2.0 fg

Unknown:

mass = ? g   mass = ? kg

End of Slide

Sample Problem, *continued*

Build conversion factors from the relationships given in **Table 3** of the textbook. Two possibilities are:

$$\frac{1\times10^{-15}\ \text{g}}{1\ \text{fg}} \quad \text{and} \quad \frac{1\ \text{fg}}{1\times10^{-15}\ \text{g}}$$

Only the first one will cancel the units of femtograms to give units of grams.

$$(2.0\ \cancel{\text{fg}})\left(\frac{1\times10^{-15}\ \text{g}}{1\ \cancel{\text{fg}}}\right) = \boxed{2.0\times10^{-15}\ \text{g}}$$

End of Slide

Sample Problem, *continued*

Take the previous answer, and use a similar process to cancel the units of grams to give units of kilograms.

$$(2.0\times10^{-15}\ \cancel{g})\left(\frac{1\ kg}{1\times10^{3}\ \cancel{g}}\right)=\boxed{2.0\times10^{-18}\ kg}$$

End of Slide

< Back | Next > | Preview | Main

Accuracy and Precision

- **Accuracy** is a description of how close a measurement is to the correct or accepted value of the quantity measured.
- **Precision** is the degree of exactness of a measurement.
- A numeric measure of confidence in a measurement or result is known as **uncertainty.** A lower uncertainty indicates greater confidence.

End of Slide

Accuracy and Precision

Click below to watch the Visual Concept.

Visual Concept

Measurement and Parallax

Click below to watch the Visual Concept.

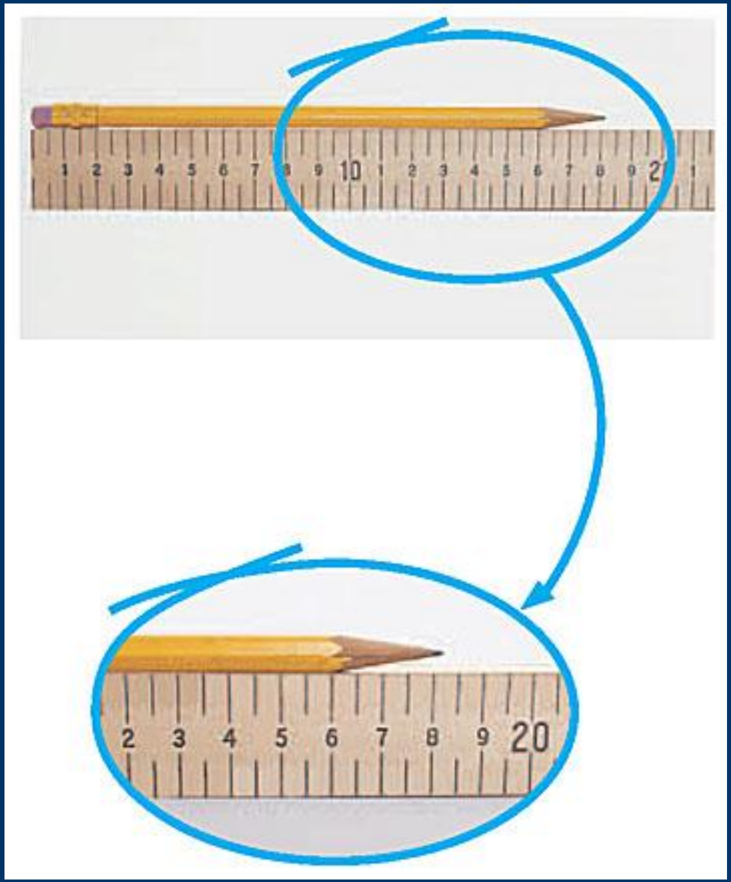
Visual Concept

Significant Figures

- It is important to record the **precision of your measurements** so that other people can understand and interpret your results.
- A common convention used in science to indicate precision is known as **significant figures.**
- **Significant figures** are those digits in a measurement that are known with certainty plus the first digit that is uncertain.

End of Slide

Significant Figures, *continued*



Even though this ruler is marked in only centimeters and half-centimeters, if you estimate, you can use it to report measurements to a precision of a millimeter.

End of Slide

Rules for Determining Significant Zeroes

Click below to watch the Visual Concept.

Visual Concept

Rules for Determining Significant Zeros

Rule	Examples
1. Zeros between other nonzero digits are significant.	**a.** 50.3 m has three significant figures. **b.** 3.0025 s has five significant figures.
2. Zeros in front of nonzero digits are not significant.	**a.** 0.892 kg has three significant figures. **b.** 0.0008 ms has one significant figure.
3. Zeros that are at the end of a number and also to the right of the decimal are significant.	**a.** 57.00 g has four significant figures. **b.** 2.000 000 kg has seven significant figures.
4. Zeros at the end of a number but to the left of a decimal are significant if they have been measured or are the first estimated digit; otherwise, they are *not* significant. In this book, they will be treated as *not* significant. (Some books place a bar over a zero at the end of a number to indicate that it is significant. This textbook will use scientific notation for these cases instead.)	**a.** 1000 m may contain from one to four significant figures, depending on the precision of the measurement, but in this book it will be assumed that measurements like this have one significant figure. **b.** 20 m may contain one or two significant figures, but in this book it will be assumed to have one significant figure.

Rules for Calculating with Significant Figures

Type of calculation	Rule	Example
addition or subtraction	Given that addition and subtraction take place in columns, round the final answer to the *first column from the left containing an estimated digit.*	97.3 + 5.85 103.15 $\xrightarrow{\text{round off}}$ 103.2
multiplication or division	The final answer has the same number of significant figures as the measurement having the *smallest* number of *significant figures.*	123 × 5.35 658.05 $\xrightarrow{\text{round off}}$ 658

Rules for Rounding in Calculations

Click below to watch the Visual Concept.

Visual Concept

Rules for Rounding in Calculations

What to do	When to do it	Examples
round down	• whenever the digit following the last significant figure is a 0, 1, 2, 3, or 4	30.24 becomes 30.2
	• if the last significant figure is an even number and the next digit is a 5, with no other nonzero digits	32.25 becomes 32.2 32.65000 becomes 32.6
round up	• whenever the digit following the last significant figure is a 6, 7, 8, or 9	22.49 becomes 22.5
	• if the digit following the last significant figure is a 5 followed by a nonzero digit	54.7511 becomes 54.8
	• if the last significant figure is an odd number and the next digit is a 5, with no other nonzero digits	54.75 becomes 54.8 79.3500 becomes 79.4

Preview

- Objectives
- Mathematics and Physics
- Physics Equations

Objectives

- **Interpret** data in tables and graphs, and recognize equations that summarize data.
- **Distinguish** between conventions for abbreviating units and quantities.
- **Use** dimensional analysis to check the validity of equations.
- **Perform** order-of-magnitude calculations.

End of Slide

Mathematics and Physics

- **Tables, graphs,** and **equations** can make data easier to understand.
- For example, consider an experiment to test Galileo's hypothesis that all objects fall at the same rate in the absence of air resistance.
  - In this experiment, a table-tennis ball and a golf ball are dropped in a vacuum.
  - The results are recorded as a set of numbers corresponding to the times of the fall and the distance each ball falls.
  - A convenient way to organize the data is to form a table, as shown on the next slide.

End of Slide

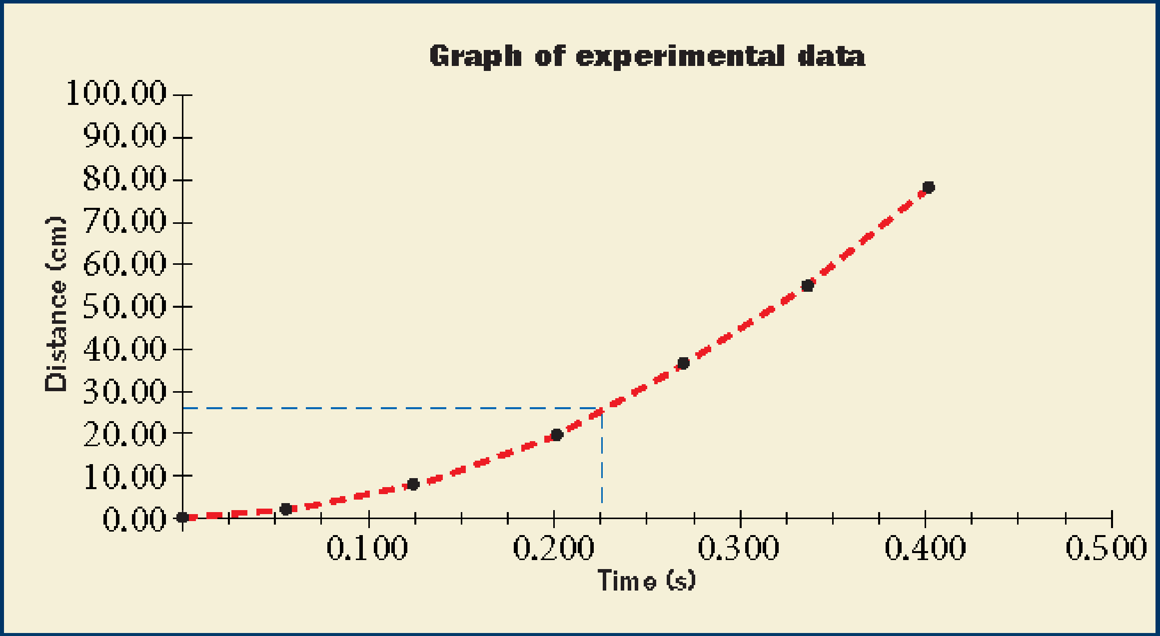
Data from Dropped-Ball Experiment

Time (s)	Distance golf ball falls (cm)	Distance table-tennis ball falls (cm)
0.067	2.20	2.20
0.133	8.67	8.67
0.200	19.60	19.59
0.267	34.93	34.92
0.333	54.34	54.33
0.400	78.40	78.39

A clear trend can be seen in the data. The more time that passes after each ball is dropped, the farther the ball falls.

Graph from Dropped-Ball Experiment

One method for analyzing the data is to construct a graph of the distance the balls have fallen versus the elapsed time since they were released. a



The shape of the graph provides information about the relationship between time and distance.

Interpreting Graphs

Click below to watch the Visual Concept.

Visual Concept

Physics Equations

- Physicists use **equations** to describe measured or predicted relationships between physical quantities.
- **Variables** and other specific quantities are abbreviated with letters that are **boldfaced** or *italicized*.
- **Units** are abbreviated with regular letters, sometimes called roman letters.
- Two tools for evaluating physics equations are **dimensional analysis** and **order-of-magnitude estimates.**

Equation from Dropped-Ball Experiment

- We can use the following equation to describe the relationship between the variables in the dropped-ball experiment:

(change in position in meters) = 4.9 × (time in seconds)^2

- With symbols, the word equation above can be written as follows:

$$\Delta y = 4.9(\Delta t)^2$$

- The Greek letter **Δ (delta)** means **"change in."** The abbreviation **Δ*y*** indicates the **vertical change** in a ball's position from its starting point, and **Δ*t*** indicates the **time elapsed.**

- This equation allows you to **reproduce the graph** and **make predictions** about the change in position for any time.

Evaluating Physics Equations

Click below to watch the Visual Concept.

Visual Concept