Preview

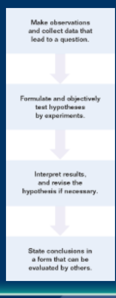
What do you think?

- What are some topics you expect to study this year in physics?
- The principles of physics govern our everyday lives. Do you know any of the laws of physics?
  - If so, describe the law or rule of physics as you understand it.
- Do the laws of physics ever change?

Table 1 Areas Within 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

Scientific Method



- Models are often used to explain the principles of physics.
- Systems are defined to study the important components.
- All experiments must be "controlled."
  - Limit the experiment to testing one factor at a time.

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Models

Click below to watch the Visual Concept.

Visual Concept

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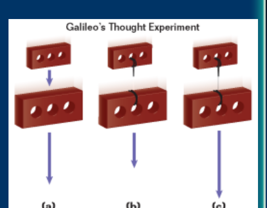
Hypotheses

- A hypothesis is a reasonable explanation for observations.
- Before Galileo, scientists believed heavy objects fell more rapidly than light objects.
- Galileo considered the situation shown.
  - If the heavy brick falls faster, what would happen if they were tied together?



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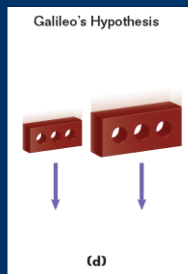
Galileo's Hypothesis

- Since the two bricks can't fall faster and slower than the heavy brick, Galileo concluded the original hypothesis was wrong.
- Galileo's hypothesis:
  - All objects fall at the same rate in the absence of air resistance.



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Now what do you think?

- What are some topics you expect to study this year in physics?
- How do scientists discover the laws of physics?
- Do the laws of physics ever change?

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What do you think?

- What system of measurement is used in physics?
- Is a measurement of 2 cm different from one of 2.00 cm?
  - If so, how?
- What is the area of a strip of paper measuring 97.3 cm x 5.85 cm? How much should you round off your answer?

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Measurements

- Dimension - the kind of physical quantity being measured
  - Examples: length, mass, time, volume, and so on
  - Each dimension is measured in specific units.
    - meters, kilograms, seconds, liters, and so on
  - Derived units are combinations of other units.
    - m/s, kg/m^3, and many others
- Scientists use the SI system of measurement.

Table 2 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

Prefixes

Table 3
Some Prefixes for Powers of 10 Used with Metric Units

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

Converting Units

- Build a conversion factor from the previous table. Set it up so that units cancel properly.
- Example - Convert 2.5 kg into g.
  - Build the conversion factor: $\frac{10^3\ \text{g}}{1\ \text{kg}}$
  - This conversion factor is equivalent to 1.
    - 10^3 g is equal to 1 kg
  - Multiply by the conversion factor. The units of kg cancel and the answer is 2500 g.

$$2.5\ \text{kg} \times \frac{10^3\ \text{g}}{1\ \text{kg}} = 2500\ \text{g}$$

- Try converting
  - .025 g into mg
  - .22 km into cm

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Classroom Practice Problem

- If a woman has a mass of 60 000 000 mg, what is her mass in grams and in kilograms?
  - Answer: 60 000 g or 60 kg

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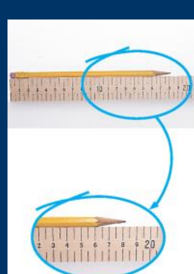
Accuracy and Precision

- Precision is the degree of exactness for a measurement.
  - It is a property of the instrument used.
  - The length of the pencil can be estimated to tenths of centimeters.
- Accuracy is how close the measurement is to the correct value.



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Errors in Measurement

- Instrument error
  - Instrument error is caused by using measurement instruments that are flawed in some way.
  - Instruments generally have stated accuracies such as “accurate to within 1%.”
- Method error
  - Method error is caused by poor techniques (see picture below).

Measurement of Parallax

Click below to watch the Visual Concept.

Visual Concept

Significant Figures

- Significant figures are the method used to indicate the precision of your measurements.
- Significant figures are those digits that are known with certainty *plus* the first digit that is uncertain.
  - If you know the distance from your home to school is between 12.0 and 13.0 miles, you might say the distance is 12.5 miles.
    - The first two digits (1 and 2) are certain and the last digit (5) is uncertain.

Rules for Determining Significant Zeros

Click below to watch the Visual Concept.

Visual Concept

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Counting Significant Figures

Rule
1. Zeros between other nonzero digits are significant.
2. Zeros in front of nonzero digits are not significant.
3. Zeros that are at the end of a number and also to the right of the decimal are significant.
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.)

- Examples
  - 50.3 m
  - 3.0025 s
  - 0.892 kg
  - 0.0008 ms
  - 57.00 g
  - 2.000 000 kg
  - 1000 m
  - 20 m
- Scientific notation simplifies counting significant figures.

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Rules for Rounding Numbers

Click below to watch the Visual Concept.

Visual Concept

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Rounding

Table 6	Rules for Rounding in Calculations
What to do	**When to do it**
round down	• whenever the digit following the last significant figure is a 0, 1, 2, 3, or 4
	• if the last significant figure is an even number and the next digit is a 5, with no other nonzero digits
round up	• whenever the digit following the last significant figure is a 6, 7, 8, or 9
	• if the digit following the last significant figure is a 5 followed by a nonzero digit
	• if the last significant figure is an odd number and the next digit is a 5, with no other nonzero digits

- Round to 3 figures:
  - 30.24
  - 32.25
  - 32.65000
  - 22.49
  - 54.7511
  - 54.75
  - 79.3500

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Calculating with Significant Figures

Type of calculation	Rule
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.*
multiplication or division	The final answer has the same number of significant figures as the measurement having the *smallest* number of *significant figures.*

- 97.3 + 5.85
- 123 x 5.35

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Now what do you think?

- What system of measurement is used in physics?
- Is a measurement of 2 cm different from one of 2.00 cm?
  - If so, how?
- What is the area of a strip of paper measuring 97.3 cm x 5.85 cm? How much should you round off your answer?

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What do you think?

- What different ways can you organize data so that it can be analyzed for the purpose of making testable predictions?

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The Science of Physics Section 3

Tables

- This table organizes data for two falling balls (golf and tennis) that were dropped in a vacuum. (This is shown in **Figure 13** in your book).
- Can you see patterns in the data?

Table 7 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

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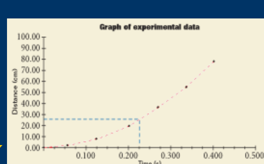
The Science of Physics Section 3

Graphs

- Data from the previous table is graphed.
- A smooth curve connects the data points.
  - This allows predictions for points between data points such as t = 0.220 s.
- The graph could also be extended.
  - This allows predictions for points beyond 0.400 s.



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Shapes of Graphs and Mathematical Relationships

Click below to watch the Visual Concept.

Visual Concept

Equations

- Show relationships between variables
  - Directly proportional
  - Inversely proportional
  - Inverse, square relationships
- Describe the model in mathematical terms
  - The equation for the previous graph can be shown as $\Delta y = (4.9)\Delta t^2$.
- Allow you to solve for unknown quantities

Dimensional Analysis

- Dimensions can be treated as algebraic quantities.
  - They must be the same on each side of the equality.
- Using the equation $\Delta y = (4.9)\Delta t^2$, what dimensions must the 4.9 have in order to be consistent?
  - Answer: length/time^2 (because *y* is a length and *t* is a time)
  - In SI units, it would be 4.9 m/s^2 .
- Always use and check units for consistency.

Order of magnitude

- Rounds to the nearest power of 10
  - The number 65 has an order of magnitude of 10^2 because it is closer to 10^2 than to 10^1
  - What is the order of magnitude for 4200, 0.052 and 6.2×10^{23}?
    - Answers: 10^3, 10^{-1} , and 10^{24}
- Allows you to get approximate answers for calculations

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Now what do you think?

- What different ways can you organize data so that it can be analyzed for the purpose of making testable predictions?

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