CHAPTER 1

SCIENTIFIC METHOD: ANALYSIS – INQUIRY – DESIGN

- ***STANDARD 1***
  Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Observation and Inference

An **observation** is a description of an object or event. For example, "this rock is shiny," "this animal has fur," and "the snowstorm lasted for six hours" are observations.

Observations are made by using the five senses. Instruments assist our senses. A telescope allows us to see objects at very long distances. Instruments are also used to make measurements. For example, "this rock has a mass of 23.4 grams" is a measurement made by using a balance.

An **inference** is a conclusion, opinion, or explanation of the observations. An inference can be a prediction about the future. The weather forecast for tomorrow is an inference.

Review Questions

1. An observation is a _____ of an object or event.
2. We observe by using our _____
3. Our senses are helped by the use of _____.
4. An _____ is a conclusion based on observations.
5. An inference can be a _____ about a future occurrence.
6. Is the statement an *observation* **(O)** or an *inference* **(I)**?
   - **a.** The road is 5.6 kilometers long. _____
   - **b.** Friction slowed the car. _____
   - **c.** This footprint was made by a dinosaur. _____
   - **d.** It will rain tonight. _____
   - **e.** This surface feels slippery. _____
   - **f.** Ice melts at 0°C. _____

Scientific Method

The **scientific method** is a series of steps used to investigate and answer questions. It is an organized plan used to solve problems. Scientists are not the only ones who use this method of investigation. We all use the scientific method to find the solutions to our questions.

STEPS IN THE SCIENTIFIC METHOD OF PROBLEM SOLVING

1	**Ask a Question**	• State the problem which needs to be solved.
2	**Develop a Hypothesis**	• Write a possible answer to the question. • Written as an : "If . . . ., then . . . ." statement: • "if . . . .(state the factor that is to be studied)", • "then . . . (suggest a possible result)". • You can often add "because . . . (why will this happen)".
3	**Design an Experiment**	• Plan a procedure that is written as a list of steps. • Include instruments to be used and measurements to be taken. • Include appropriate safety procedures. • A **controlled experiment** will test only one factor. • The factor which you purposely change during the experiment is the **manipulated (independent) variable.** • The variable which changes as a result of the experiment is the **responding (dependent) variable.** • All other factors in the experiment remain constant.
4	**Perform the Experiment**	• Make observations and collect data. • Use a data chart.
5	**Interpret Data**	• Explain the observations. • Identify sources of error. • Include graphs, diagrams, and calculations.
6	**Form a Conclusion**	• The conclusion is based on the observations and data collected. The conclusion should answer the question and compare the results to the hypothesis.
7	**Write a Report**	• This is the way that data and results are shared with others.

During a science investigation one must be careful and cautious in the laboratory. Established rules and procedures must be followed and all safety precautions should be considered.

Review Questions

7. The first step in scientific method is to ask a _____.
8. A possible answer to the problem is a _____.
9. A controlled experiment tests only _____ factor.
10. The variable which you change is the _____ variable.
11. The data you collect is the _____ variable.
12. A conclusion is based on _____ and _____ collected.
13. A student wonders if the color of the light will affect how a plant grows.
    a. Write a Question: _____
    b. Develop a Hypothesis: _____
    c. State the factor that should be changed in the experiment: _____
    d. State the factor that will be observed during the experiment: _____
    e. List THREE factors that should remain the same during the experiment:
       (1) _____
       (2) _____
       (3) _____
    f. Write a procedure for an experiment to test the hypothesis : _____
       _____

Metric Measurement

Measurement is an observation and description using numbers. All measurements are usually rounded to the nearest tenth and have a unit. For example, a measured mass of 35.68 should be written as 35.7 grams.

Scientific notation is a method used to write very large or very small numbers in a simpler form. In scientific notation, 2,300,000,000 kilometers would be written as 2.3×10^9 km. The number 0.000000074 meters would be written as 7.4×10^{-8} m.

The metric system is used in science and in most countries of the world. It is based on the number ten. The metric system uses prefixes with each unit of measurement.

"Milli" is the prefix used for small measurements. For example, the width of a string would be measured in millimeters. "Kilo" is the prefix used for large measurements. A horse's mass would be measured in kilograms.

Common Metric Prefixes

kilo...	1000
centi...	$1/100^{th}$ or 0.01
milli...	$1/1000^{th}$ or 0.001

COMMON MEASUREMENTS

TIME	
DEFINITION	the period during which something happens
INSTRUMENT(S) USED	stopwatch, clock
UNIT OF MEASUREMENT	second (s)

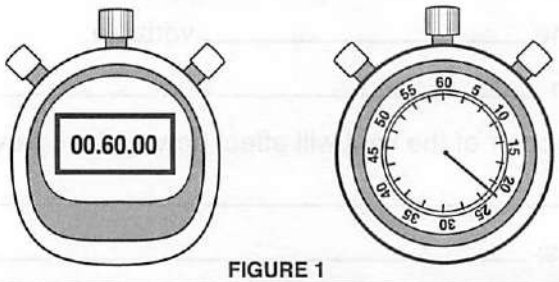


FIGURE 1

TEMPERATURE	
DEFINITION	average motion of molecules
INSTRUMENT(S) USED	thermometer
UNIT OF MEASUREMENT	degree Celsius (°C)

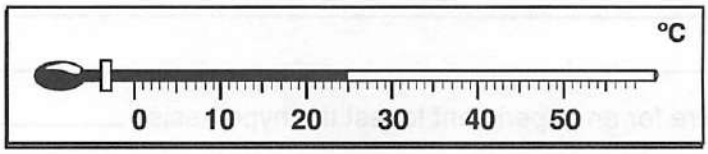


FIGURE 2

LENGTH	
DEFINITION	distance between two points
INSTRUMENT(S) USED	ruler
UNIT OF MEASUREMENT	meter (m), centimeter (cm), millimeter (mm)

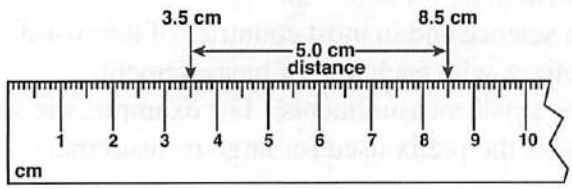


FIGURE 3

MASS	
DEFINITION	amount of matter in an object
INSTRUMENT(S) USED	balance
UNIT OF MEASUREMENT	gram (g), kilogram (kg)

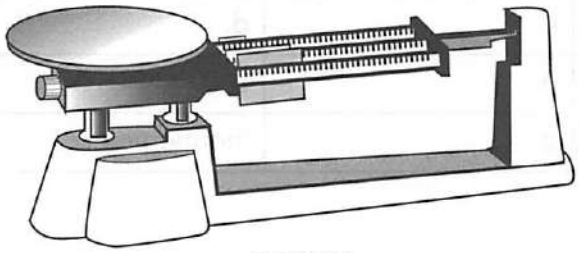
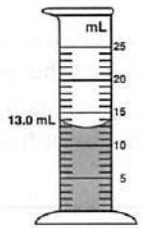
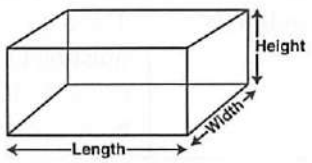


FIGURE 4

VOLUME	
DEFINITION	amount of space an object occupies
INSTRUMENT(S) USED	(a) graduated cylinder for liquids (b) ruler for rectangular solids; V = L × W × H (c) water displacement in a graduated cylinder for irregular objects
UNIT OF MEASUREMENT	(a) Liter (L) (b) cubic centimeter (cm^3) (c) milliliter (mL)



GRADUATED CYLINDER FOR LIQUIDS
FIGURE 5a



CALCULATION OF A RECTANGLE
FIGURE 5b

Review Questions

14. Round these numbers to the nearest tenth:

a. 56.72 = _____ **b.** 8.37 = _____ **c.** 135.78 = _____

15. Write these numbers in scientific notation:

a. 5,400,000 = _____ **b.** 0.00000062 = _____ **c.** 100,000 = _____

16. Write the number represented:

a. 7.8×10^4 = _____ **b.** 4.28×10^{-3} = _____

17. One kilogram equals _____ grams.

18. Complete the following chart:

Object	Data	Measurement of ...	Instrument (method used)
Box	58.7 cm^3	**a.**	ruler (L x W x H)
Flagpole	118.2 m	length	**b.**
Paper Clip	2.6 g	**c.**	**d.**
Milk	83.7 mL	**e.**	**f.**
Air in Room	20.0° C	**g.**	thermometer

Graphing

Graphs show the relationship between the variables. Graphs show how the responding variable has changed. They may show a pattern.

STEPS IN CONSTRUCTING A LINE GRAPH

1	**Label the X- axis**	The first factor listed in the data chart is the manipulated (independent) variable. This is labeled on the horizontal axis.
2	**Label the Y-axis**	The second factor on the data chart is the responding (dependent) variable. This is labeled on the vertical axis.
3	**Label the unit of measurement**	On each axis write the unit of measurement that was used. This is often placed in parenthesis "( )".
4	**Number each axis**	The data collected must fit along each axis of the graph. The axis must be numbered with the same interval such as by 2s (2, 4, 6,...) or 5s (5, 10, 15,...). The same interval does not have to be used on both axes.
5	**Plot the data**	Accurately place a point for each set of data.
6	**Draw a line**	Draw the best fit line for the data plotted or connect the data points.
7	**Title the Graph**	Write a title for the graph based on the type of data collected.

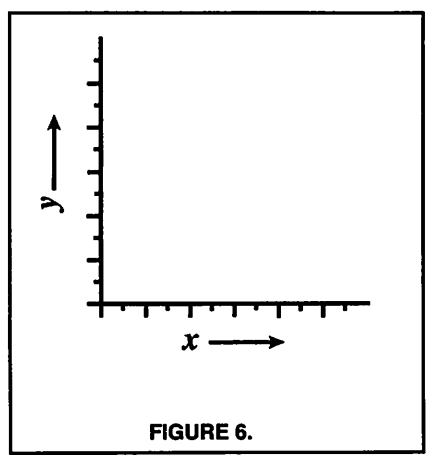


FIGURE 6.

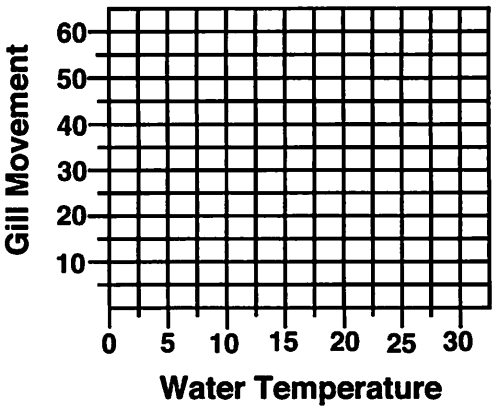
Review Questions

19. A data chart and its corresponding graph is shown below.

a. Name the two parts of the graph that are missing. _____ and _____.

b. Complete the graph.

Water Temperature (°C)	Gill Movement (openings/minute)
10	15
15	25
18	30
20	38
23	60
25	57
27	25



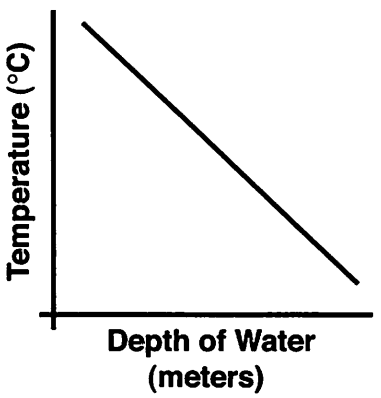
20. The horizontal axis is the _____ variable.

21. The _____ axis is the responding variable.

22. Axes are numbered using the _____ interval.

23. Each axis is labeled with the _____ and the _____.

24. Refer to the graph below:



a. The manipulated variable is _____.

b. The responding variable is _____.

c. A good title would be _____.

d. As the depth of water increased, the temperature _____.

VOCABULARY

conclusion

control

data

hypothesis

inference

length

manipulated (independent) variable

mass

measurement

observation

responding (dependent) variable

scientific method

scientific notation

variable

volume