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)

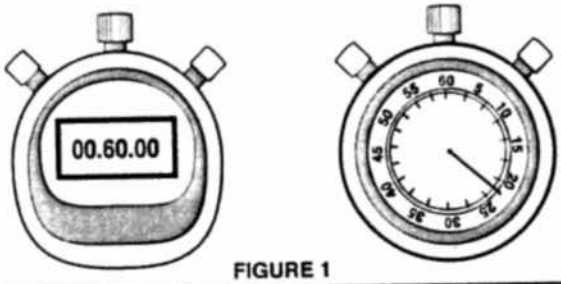


FIGURE 1

TEMPERATURE

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

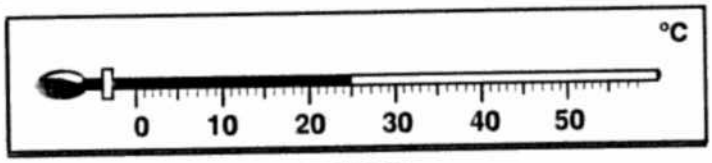


FIGURE 2

LENGTH

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

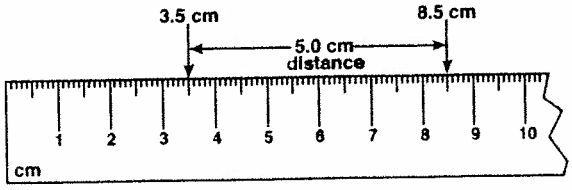


FIGURE 3

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

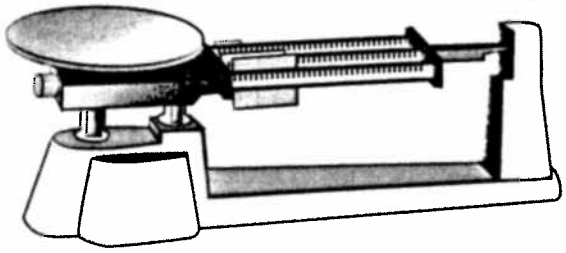
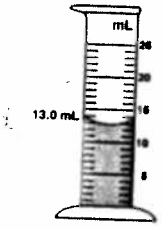
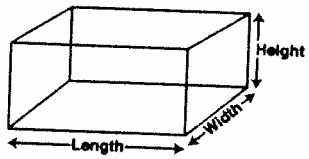


FIGURE 4

VOLUME	
DEFINITION	amount of space an object occupies
INSTRUMENT(S) USED	(a) graduated cylinder for liquids (b) ruler for rectangular solids; $V = L \times W \times H$ (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.

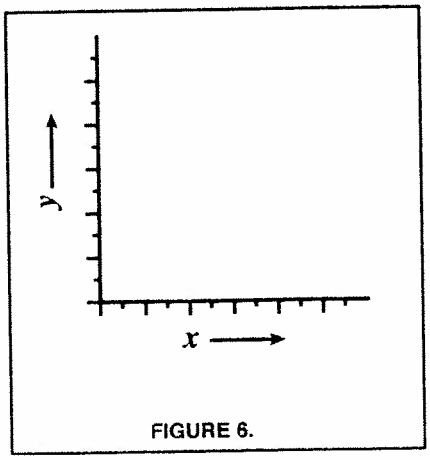


FIGURE 6.

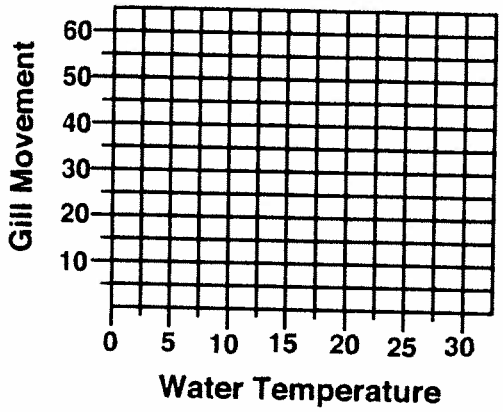
Review Questions

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



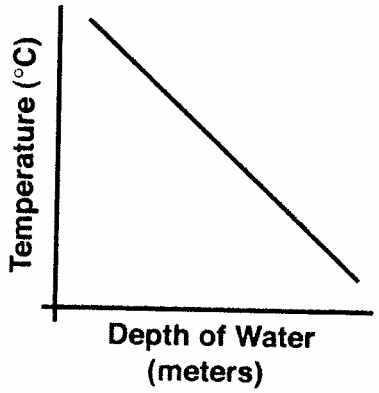
20. The horizontal axis is the _____ variable.

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 _____.

CHAPTER REVIEW

1. A student visits a stream. The student writes down four statements in his notebook. Which statement is an inference?
   (1) The maximum water depth is 8.7 meters.
   (2) The water is so clear that I can see the bottom.
   (3) The stream was formed during the last Ice Age.
   (4) The water temperature is 16.0° C.

2. A student is rolling a ball down a ramp. Which statement is an observation?
   (1) If the ramp is steeper, then the ball will roll faster.
   (2) Friction slowed the ball.
   (3) Gravity caused the ball's motion down the ramp.
   (4) The ball rolled 86.3cm. in 3.0 seconds.

3. Which set of items could be used to make observations during an experiment?
   (1) sight, ruler, stopwatch
   (2) sight, graph paper, calculator
   (3) sight, touch, textbook
   (4) touch, ruler, notebook

4. An orderly process used to solve problems and investigate the world is
   (1) technology (2) scientific method (3) prediction (4) theory

5. A student decides to enter a science contest that requires an original research project. What is the first step she must take in doing the research?
   (1) design an experiment
   (2) write a conclusion
   (3) state the problem to which she wants to find an answer
   (4) collect data in an organized chart

6. The information that has been collected through observation and measurement is called the
   (1) data (2) conclusion (3) variables (4) theory

7. In an experiment, the factor that is being tested and changed is the
   (1) data (2) control (3) variable (4) inference

8. Diagrams, tables, and graphs are used by scientists mainly to
   (1) design a procedure
   (2) test a hypothesis
   (3) organize data
   (4) predict the independent variable

9. All of the following are safe procedures to follow when heating a beaker of water *except* :
   (1) use heat-resistant gloves
   (2) watch the beaker as it is heated
   (3) remove your goggles when you put the beaker on the hot plate
   (4) keep the counter clear of papers

10. The length of a sneaker is best measured in:
    (1) millimeters (2) centimeters (3) meters (4) kilometers

11. The mass of a very large boulder is best expressed in:
    (1) milligrams (2) centigrams (3) grams (4) kilograms

Base your answers to **questions 12-14** on the following paragraph:

In a science experiment, 10 bean seedlings were placed in the dark and another 10 bean seedlings were placed in sunlight. All other growth conditions were kept the same for both sets of seedlings. After one week it was observed that the seedlings in the dark were white with long slender stems. The seedlings in the sunlight were green and healthy.

12. The manipulated (independent) variable in this experiment was the:
(1) number of bean seedlings
(2) amount of light
(3) temperature
(4) size of the seedlings

13. The "growth conditions" that were kept the same are called:
(1) constants (2) predictions (3) observations (4) inferences

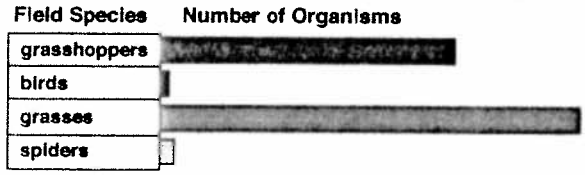
14. Which conclusion can be made from this experiment?
(1) Plants grown in the dark can not carry on respiration.
(2) Light is necessary for proper water absorption by roots.
(3) Light is necessary for the germination of bean seeds.
(4) Light is needed for the normal growth of seedlings.

15. An ecologist determined the population size of several species during May, June, and July. The results are in the data table below.

Field Species	Number of Organisms		
	May	July	August
grasshoppers	1,000	5,000	1,500
birds	250	100	100
grasses	7,000	20,000	6,000
spiders	75	200	500

Which graph best represents each specie's population for May?

(1)



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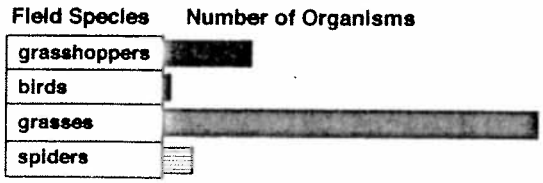

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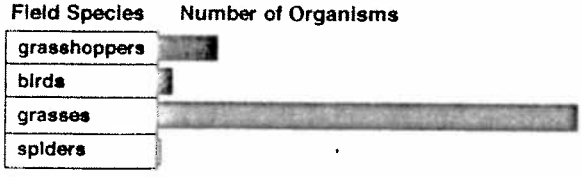
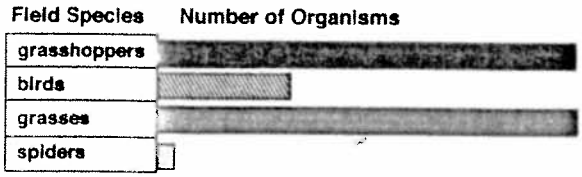


(4)



EXTENDED RESPONSE

16. A student performed a laboratory experiment to determine the effect of temperature on the heart rate of a water flea. The following temperatures and heart rates were recorded:

20°C - 260 beats/min
10°C - 154 beats/min
15°C - 200 beats/min
25°C - 300 beats/min
5°C - 102 beats/min

a. Organize the data into a data table (include title for each variable)

b. State the manipulated (independent) variable in this experiment. _____

c. Write a statement based on the data that describes the relationship between temperature and heart beat in the water flea.

_____

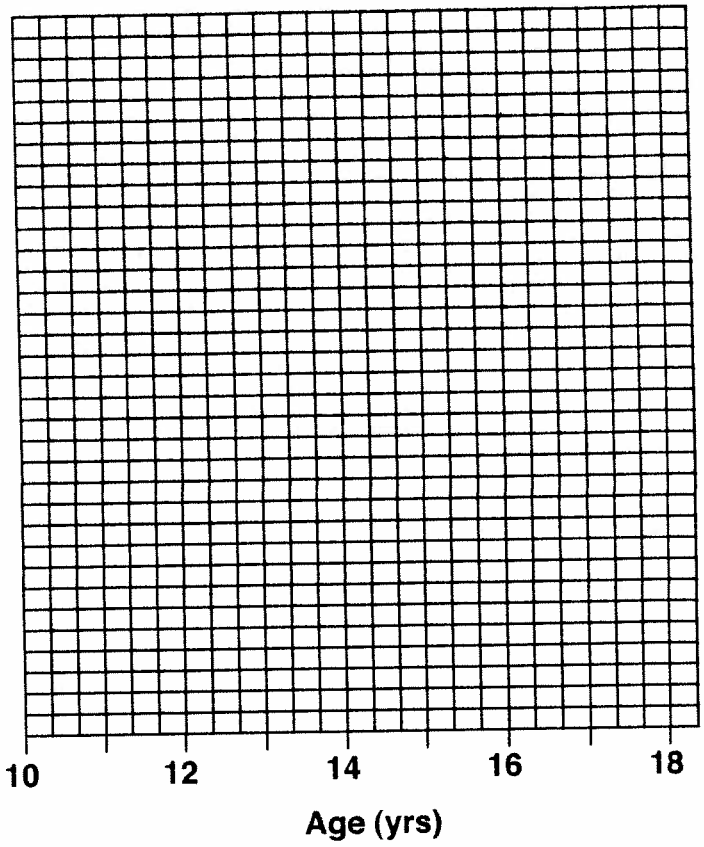
_____

_____

17. A student did research on the average Calorie requirements for adolescents. He organized the data table as shown below.

Calories Required Each Day

Age	Boys	Girls
11	2500	2300
12	3000	2500
13	3200	2900
14	3400	2800
15	3500	2700
16	3650	2700
17	3800	2700
18	3000	2500



a. On the graph, label the vertical axis "*Calories per day*".

b. Mark an appropriate scale for the vertical axis.

c. Plot the data for the "boys" using a point surrounded by a circle (⊙). Connect the points with a solid line. Label the line *"boys"*

d. Plot the data for the "girls" using a point surrounded by a triangle (◬). Connect the points with a dashed line. Label the line *"girls"*.

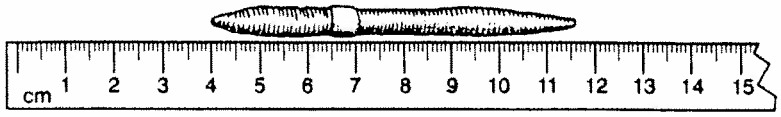
e. State the responding (dependent) variable. _____

f. Write an appropriate title for this graph. _____

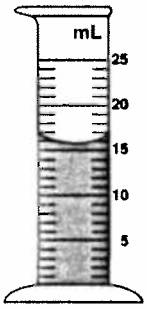
g. Contrast the Calories required for boys and for girls. _____

_____

18. Determine the length of the earthworm as shown in the diagram. _____



19. Write the volume of the liquid shown.



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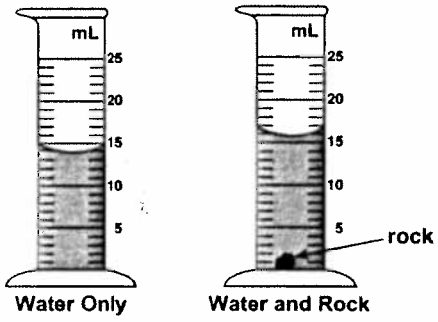
20. Determine the volume of the rock.



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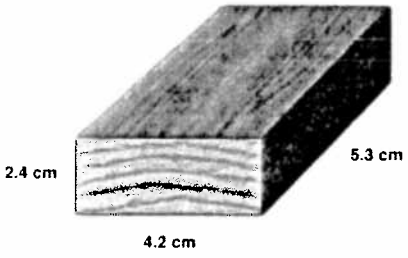
21. Calculate the volume of the block of wood



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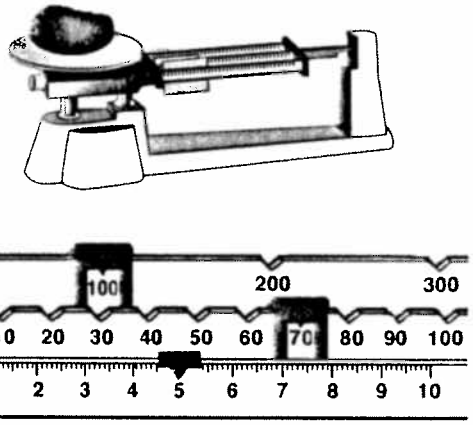
22. Record the mass indicated on the balance.



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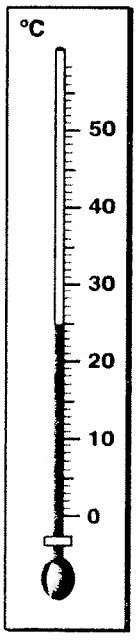
23. Record the temperature indicated.



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