Chapter 1

Solutions to Supplementary *Check for Understanding* Problems

Scientific Method

1. Do you agree with the following statement: "A scientific law is a mathematical statement of a scientific theory."? Briefly explain your answer.

Solution

Disagree. Many theories contain mathematical statements that summarize existing observations, however, a scientific law, unlike a theory, is not an explanation of observations so it is not a theory in any form.

2. "Heat flows from a hotter object to a cooler one". Is this statement a scientific law or a theory? Explain.

Solution

This statement is a law because it summarizes our observations. It is not a theory because it does not explain why the transfer of heat occurs this way.

3. Imagine you want to see what color of bird feeder your local birds prefer and you plan a series of experiments. What would be the independent variable in your experiments. What would be the dependent variable? What factors should you keep constant?

Answers: independent variable - color of the bird feeder

dependent variable - amount of seed eaten

constant factors - location of feeder, kind of seed used, time when feeder is put out, amount of seed placed in feeder

Solution

The independent variable is the factor that is changed by the person doing the experiment. In this case it is the color of the feeder. The dependent variable is the factor that is measured in response to changes in the independent variable. In this case it is the amount of birdseed consumed. All of factors are keep the same (constant). These include the location of the feeder, the kind of seed used, when the feeder is put out and the amount of seed placed in the feeder. Additional factors might have to be allowed for such the weather and the presence of other animals.

4. Suppose you want to test the effectiveness of various materials such as sunscreen lotions, clothing and sunglasses in shielding you from the ultraviolet radiation in sunlight. Describe an experiment you could do to test the effectiveness of these materials. What would serve as your control experiment? Will this be a quantitative or qualitative determination of the effectiveness of the sunscreen materials?

Solution

Sunlight can serve as the source of ultraviolet radiation, however, you need some sort of "sensor" that indicates how much ultraviolet radiation is passing through the various test materials. If you have skin that tans or reddens easily you might use this as your sensor. Otherwise, you might consider using UV-sensitive plastic beads. These beads contain a substance embedded in the plastic that rapidly changes color when exposed to UV radiation. When the beads are removed from sunlight the color quickly fades. The beads are not affected by visible light, such as that emitted from a light bulb, and remain white or pale as long as they are kept away from sunlight.

If you are able to use your skin as the sensor, you might place samples of the various test materials along each arm in a random order by taping them or applying them as lotions to your skin. Then go outside for a time long enough to cause reddening of your skin. When you come inside, remove the samples and assess the degree of reddening at each test sample location relative to that for uncovered skin adjacent to each sample (the control). This sort of result is qualitative since no numerical data are collected. A similar comparison could be done with covered and uncovered UV-sensitive plastic beads.

5. Your friend Anna wanted to see if a new gasoline would give more miles per gallon so she filled up her car's gas tank and went for a long drive. When she figured the gas mileage she discovered that she went 25 miles further on a tank of this gas than she did on a tank of her regular gas when she drove around town as usual. She decided to buy the new gas (same price as other gas) in order to get better mileage. Do you agree with her decision? Explain your thinking.

Solution

Disagree. Anna's comparison of the two gasolines lacks an appropriate control. Gas mileage depends on many factors such as average speed and road conditions. In order to make a valid comparison she should determine the gas mileage for each brand of gas while driving under similar conditions.

6. Provide an alternative hypothesis to the one listed below to account for the evidence observed.

   Evidence: Children from high socioeconomic households have, on the average, higher grades in school.

   Hypothesis: Money causes good grades.

Solution

An alternative hypothesis must be consistent with all of the evidence. Some possibilities are:

- Children from high socioeconomic households have more resources such as computers and tutors to help them achieve higher grades.
- Children from high socioeconomic households can spend more time studying because they do not have to work as much.

7. Identify two advantages (strengths) associated with the use of the scientific method.

Solution

There are numerous correct answers. Several are given below.

- The scientific method is based on observation, not supposition or beliefs.
- The scientific method is self correcting. This minimizes bias.
- The ultimate goal of the scientific method is obtaining new knowledge that is well supported by facts.
- Scientific statements tend to be precise and unambiguous.

8. In a television interview an individual claims to have "developed a new theory about the health effects of long-term mobile phone use". Explain what is wrong with this statement? How would you correct this statement?

Solution

A single individual cannot develop a scientific theory. This requires repeated testing and confirmation by many individuals. This statement is better worded as "developed a new **hypothesis** about the health effects of long-term mobile phone use".

Pseudoscience

1. Suppose, as a parent of a newborn, you hear from television programs and Internet articles that there is a link between childhood immunizations and type 1 and type 2 diabetes. Meanwhile, your child's pediatrician claims there is no scientific basis for these claims. What would be your response in order to making an informed decision about this matter?

Solution

First, investigate the source of the claims. Many of such Internet articles are found in "peer-reviewed", "open" journals published by Bentham Science Publishers. Bentham charges the author a fee and then makes access to the article free. The quality of the peer-review process at Bentham has been questioned after a completely nonsensical computer science paper was accepted for publication along with the solicitation of peer reviewers for fields outside their area of expertise. A good starting point is to search well established medical resources such as the Centers for Disease Control (CDC), the National Institutes of Health (NIH) or the Mayo Clinic for information.

Representing Quantitative Information

1. For a rectangle of constant area, how would you describe the relationship between the length and width of the rectangle? Explain.

Solution

The area (A) of a rectangle is found by multiplying the length (L) times the width (W); that is, $A = L \times W$. If the area is constant, then one can write:

$$A = \text{constant} = L \times W$$

This can be rearranged to give:

$$L = \frac{\text{constant}}{W}$$

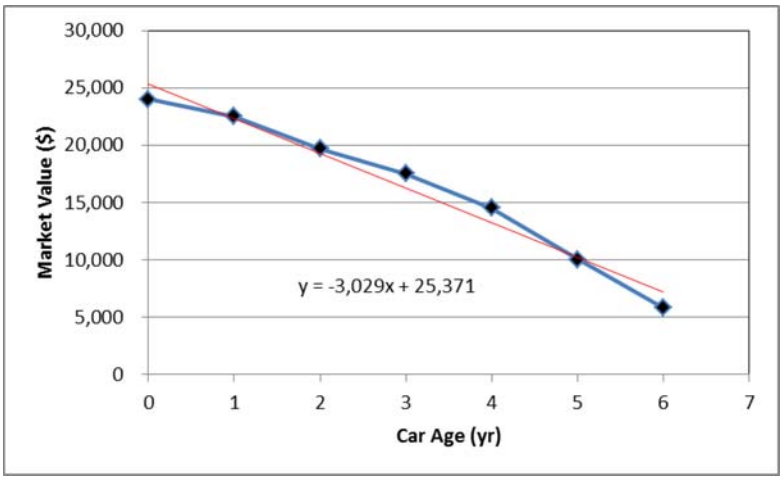
This indicates that L and W are inversely proportional since L will increase as W decreases.

2. A car was purchased in 2001 for $24,000 and the market value of the car as a function of age (year after purchase) is listed below. Is there a linear relationship between market value and the age of the car? Explain why or why not.

Year	Market value
2001	$24,000
2002	$22,500
2003	$19,700
2004	$17,500
2005	$14,500
2006	$10,000
2007	$5,800

Solution

No. A plot of market value versus car age is shown below. While there is a general trend toward lower values with increasing age, the straight line fit to the plotted data is not very good. The slope of the straight line (-3029 $/yr) indicates that there should be an approximately $3,000 decrease in the market value each year. The data show a yearly decrease that changes quite significantly (from $1,500 to $4,500) depending on the year. Also, the equation for the straight line suggests that the market value of the car will be zero after about 8.4 years (solve for x when $y = 0$) which is not very likely. Finally, there is no fundamental reason why there should be a linear relationship between the market value and the age of the car.



3. For each of the following data sets, which quantity should be plotted on the *x*-axis. Explain.

   a) temperature (°C) and density of water

   b) for several countries, cigarette consumption (per person per year) and deaths from lung cancer (per million persons per year)

Solutions

a) Plot temperature on the *x*-axis. Density depends on the temperature so temperature is the independent variable and is plotted on the *x*-axis.

b) Plot cigarette consumption on the *x*-axis. The expectation is that smoking leads to cancer so cigarette consumption is the independent variable and is plotted on the *x*-axis.

4. Assume you need a rental truck and have a choice between Truck A, at a cost of $4.25/mile, and Truck B, at a cost of $200 + $2.00/mile. Approximately how far must you travel in order for Truck B to begin to be the more economical choice? Show all work.

Solution

Let y_A = total cost for Truck A = n($4.25/mi) where n = total miles traveled

Let y_B = total cost for Truck B = n($2.00/mi) + $200 where n = total miles traveled

For very short distances Truck B obviously costs much more. The cost will be the same for both trucks when $y_A = y_B$.

$y_A = y_B$

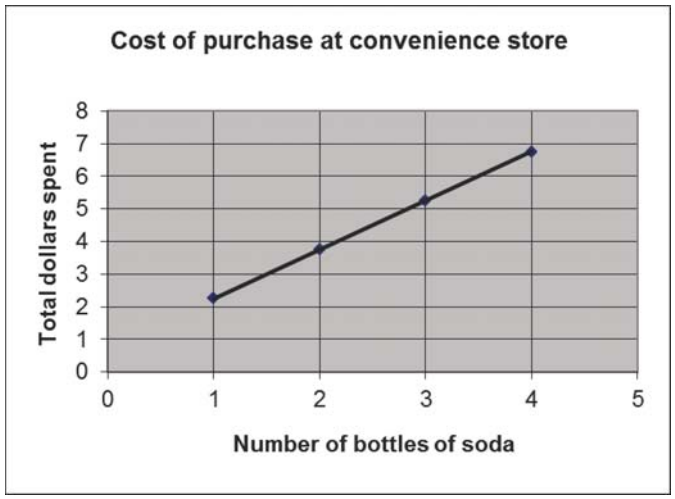
n($4.25/mi) = n($2.00/mi) + $200

n($2.25/mi) = $200

n = 88.9 mi Therefore, Truck B will be more economical for trips exceeding 90 mi.

5. a) The local convenience store sells bottles of soda for $1.50 each. Write an equation to represent how much you spend at the store for some soda and a single bag of chips. Define all terms.

   b) Use the information provided by the graph below to determine the cost of a bag of chips at this store. Show all work.



Solutions

a) y = n($1.50/bottle) + b where y = total dollars spent
n = number of bottles of soda
b = dollar cost of a bag of chips

b) From the graph, the total cost for 2 bottles of soda and a bag of chips is $3.75. Substituting into the equation above gives

$3.75 = 2 bottles($1.50/bottle) + b

b = $0.75

6. a) Assume the perimeter of a rectangle is 100 ft and the length of the rectangle is x ft. Write a mathematical expression for the width (y) of this rectangle.

   b) If you plot the rectangle width versus the rectangle length, what is the numerical value of the slope of the straight line through the data?

Solutions

a) The perimeter of a rectangle equals twice the length (x) plus twice the width (y).

Therefore, $2x + 2y = 100$ ft

rearranging gives: $2y = 100 \text{ ft} - 2x$

dividing both sides by 2 gives: $y = 50 \text{ ft} - x$

b) From the equation above, $y = -x + 50$ ft, which is in the form of an equation for a straight line ($y = mx + b$).

Therefore, the slope m equals -1 and has units of (ft of width/ft of length).