Measurement and Data Analysis for Engineering and Science 4th edition Dunn Solutions Manual

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Chapter 3

Experiments Solutions

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Review Problem 3.1

Statement: Variables manipulated by an experimenter are (a) independent, (b) dependent, (c) extraneous, (d) parameters, or (e) presumed.

Solution: (a) independent

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Review Problem 3.2

Statement: Immediately following the announcement by the University of Utah, on March 23, 1989, that Stanley Pons and Martin Fleischmann had "discovered" cold fusion, scientists throughout the world rushed to perform an experiment that typically would be classified as (a) variational, (b) validational, (c) pedagogical, (d) explorational, or (e) serendipitous.

Solution: (b) validational

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Review Problem 3.3

Statement: If you were trying to perform a validational experiment to determine the base unit of mass, the gram, which of the following fluid conditions would be most desirable? (a) a beaker of ice water, (b) a pot of boiling water, (c) a graduated cylinder of water at room temperature, (d) a thermometer filled with mercury.

Solution: (a) a beaker of ice water

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Review Problem 3.4

Statement: Match the following with the most appropriate type of variable (independent, dependent, extraneous, parameter, or measurand): (a) measured during the experiment, (b) fixed throughout the experiment, (c) not controlled during the experiment, (d) affected by a change made by the experimenter, (e) changed by the experimenter.

Solution:

- independent matches (e), changed by the experimenter
- dependent matches (d), affected by a change made by the experimenter
- extraneous matches (c), not controlled during the experiment
- parameter matches (b), fixed throughout the experiment
- measureand matches (a), measured during the experiment

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Review Problem 3.5

Statement: What is the main purpose of the scientific method?

Solution:

To validate a particular hypothesis, and, in the process, to determine the range of validity of that hypothesis.

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Review Problem 3.6

Statement: Classify the following experiments: (a) estimation of the heating value of gasoline, (b) measuring the stress-strain relation of a new bio-material, (c) the creation of Dolly (the first sheep to be cloned successfully).

Solution:

(a) Validational; Variational if the heating value is not known *a priori*.
(b) Variational
(c) Explorational

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Review Problem 3.7

Statement: An experiment is performed to determine the velocity profile along a wind tunnel's test section using a pitot-static tube. The tunnel flow rate is fixed during the experiment. Identify the independent, dependent, extraneous, and parameter variables from the following list: (a) tunnel fan revolutions per minute, (b) station position, (c) environment pressure and temperature, (d) air density, (e) change in pressure measured by the pitot-static tube, (f) calculated velocity.

Solution:

(a) Parameter
(b) Independent
(c) Either Independent or Extraneuos
(d) Dependent
(e) Dependent
(f) Dependent

The flow rate is fixed by maintaining a constant rpm of the fan that controls the air flow through the tunnel. This implies that the tunnel average velocity is constant because the tunnel cross-sectional area is constant. The change in pressure measured using the pitot-static tube is the dynamic pressure, which is the total pressure minus the static pressure. The change in pressure equals the product of one-half the density times the velocity squared (through Bernoulli's equation). The static pressure is related to the density, specific gas constant, and the temperature by the ideal gas law.

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Homework Problem 3.1

Statement: Give one historical example of an inductivistic, a fallibilistic and a conventionalistic experiment. State each of their significant findings.

Homework Problem 3.2

Statement: Write a brief description of an experiment that you have performed or are familiar with, noting the specific objective of the experiment. List and define all of the independent and dependent variables, parameters, and measurands. Also provide any equation(s) that involve the variables and define each term.

Homework Problem 3.3

Statement: Give one historical example of an experiment falling into each of the four categories of experimental purpose. Describe each experiment briefly.

Homework Problem 3.4

Statement: Write a brief description of the very first experiment that you ever performed. What was its purpose?

Homework Problem 3.5

Statement: What do you consider to be the greatest experiment ever performed? Explain your choice. You may want to read about the 10 'most beautiful experiments of all time' voted by physicists as reported by George Johnson in the *New York Times* on September 24, 2002, in an article titled "Here They Are, Science's 10 Most Beautiful Experiments." Also see R.P. Crease, 2003. *The Prism and the Pendulum: The Ten Most Beautiful Experiments in Science*. New York: Random House.

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Homework Problem 3.6

Statement: Select one of the 10 most beautiful physics experiments. (See *http://physics-animations.com/Physics/English/top_ref.htm*). Explain briefly the experiment and classify its type. Then list the variables involved in the experiment. Finally, classify each of these variables.

Solution:

This depends upon the experiment chosen. The answer should include a description of the experiment and the classifications of its type (variational, validational, pedagogical, or exploratory) and its variables (independent, dependent, parameter, measureand).

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Homework Problem 3.7

Statement: Measure the volume of your room and find the number of molecules in it. Is this an experiment? If so, classify it.

Solution:

Known:

The ideal gas equation: $p = nkT$.

Analysis:

The molecular concentration of air is $n = \frac{p}{kT}$.

Number of molecules: $N = nV$, where V is the volume of the room.

For normal conditions, $n = \frac{p}{kT} = \frac{100 \text{ kPa}}{\left(1.38\times10^{-23} \frac{\text{J·mol}}{\text{K}}\right)(300 \text{ K})} = 10^{26}$ molecules/m^3.

This is not an experiment because we do not intervene with the process under investigation.

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Homework Problem 3.8

Statement: Classify these types of experiments: (a) measuring the effect of humidity on Young's modulus of a new 'green' building material, (b) demonstrating the effect of the acidity of carbonated soda by dropping a dirty penny into it, (c) determining whether a carbon nanotube is stronger than a spider web thread.

Solution:

Analysis:

(a) Variational

(b) Pedagogical

(c) Either Validational or Explorational

Comments:

Often, a specific experiment can fall into more than one category.

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Homework Problem 3.9

Statement: Consider an experiment where a researcher is attempting to measure the thermal conductivity of a copper bar. The researcher applies a heat input q'' to a copper bar and uses four thermocouples to measure the local bar temperature $T(x)$. The thermal conductivity, k_{th}, can be calculated from the equation

$$q'' = -k_{th}\frac{dT}{dx}.$$

Variables associated with the experiment are the (a) thermal conductivity of the bar, (b) heater input, (c) temperature of points 1, 2, 3, and 4 from the thermocouples, (d) pressure and temperature of the surrounding air, (e) smoothness of copper bar at the interfaces with the heaters, and (f) position of the thermocouples. Determine whether each variable is dependent, independent, or extraneous. Then determine whether each variable is a parameter or a measurand.

Solution:

Analysis:

(a) Dependent, Parameter

(b) Independent, Parameter

(c) Dependent, Measureand

(d) Extraneous, Parameter

(e) Extraneous, Parameter

(f) Independent, Parameter

Comments:

Often, a specific variable can fall into more than one category.

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