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**Solution Manual for Introduction to Engineering Experimentation 3rd Edition by Wheeler**

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1.1 (a) The weight of a person is 175 pounds which is equivalent to 778 Newtons.

$$175 \text{ lb} \cdot \frac{4.4482 \text{ N}}{1 \text{ lb}} = 778 \text{ Newtons}$$

(b) The magnetic force of 1,200 dynes is equivalent to 0.0027 pounds or 0.012 Newtons.

$$1200 \text{ dyn} \cdot \frac{10^{-5} \text{ N}}{1 \text{ dyn}} = 0.012 \text{ Newtons}$$

$$1200 \text{ dyn} \cdot \frac{10^{-5} \text{ N}}{1 \text{ dyn}} \cdot \frac{1 \text{ lb}}{4.4482 \text{ N}} = 0.0027 \text{ pounds}$$

(c) The force exerted by the spring is 10 Newtons which is equivalent to 1,000,000 dynes or 2.248 pounds.

$$10 \text{ N} \cdot \frac{10^7 \text{ dyn}}{1 \text{ N}} = 1,000,000 \text{ dyne}$$

$$10 \text{ N} \cdot \frac{1 \text{ lb}}{4.4482 \text{ N}} = 2.248 \text{ pounds}$$

1.2 (a) The tire pressure is 30 psig which is equivalent to 2.069 bars or 2.041 atm.

$$\text{Note: } 1 \text{ psig is considered to be } = 1 \text{ psi}$$

$$30 \text{ psig} \cdot \frac{1 \text{ atm}}{14.696 \text{ psi}} = 2.041 \text{ atm}$$

$$30 \text{ psig} \cdot \frac{6.895 \text{ kPa}}{1 \text{ psi}} = 2.069 \text{ bars}$$

(b) The compressed air at 10 bars is equivalent to 145 psig or 9.87 atm or 295.3 inches of mercury or 102 meters of water.

$$10 \text{ bars} \cdot \frac{100 \text{ kPa}}{1 \text{ bar}} \cdot \frac{1 \text{ psi}}{6.895 \text{ kPa}} = 145 \text{ psi}$$

$$10 \text{ bars} \cdot \frac{100 \text{ kPa}}{1 \text{ bar}} \cdot \frac{1 \text{ atm}}{6.895 \text{ kPa}} = 9.87 \text{ atm}$$

$$10 \text{ bars} \cdot \frac{100 \text{ kPa}}{1 \text{ bar}} \cdot \frac{1 \text{ psi}}{6.895 \text{ kPa}} \cdot \frac{1 \text{ atm}}{14.696 \text{ psi}} \cdot \frac{76 \text{ cm Hg}}{1 \text{ atm}} \cdot \frac{1 \text{ in}}{2.54 \text{ cm}} = 295.3 \text{ in of Hg}$$

$$10 \text{ bars} \cdot \frac{100 \text{ kPa}}{1 \text{ bar}} \cdot \frac{1 \text{ psi}}{6.895 \text{ kPa}} \cdot \frac{1 \text{ atm}}{14.696 \text{ psi}} \cdot \frac{1033 \text{ cm Water}}{1 \text{ atm}} \cdot \frac{1 \text{ m}}{100 \text{ cm}} = 102 \text{ meters water}$$

(c) 50 cm of water is equivalent to 0.0490 bars or 0.711 psi or 1.45 inches of mercury.

$$50 \text{ cm Water} \cdot \frac{1 \text{ atm}}{1033 \text{ cm Water}} \cdot \frac{101.325 \text{ kPa}}{1 \text{ atm}} \cdot \frac{1 \text{ bar}}{100 \text{ kPa}} = 0.0490 \text{ bars}$$

$$50 \text{ cm Water} \cdot \frac{1033 \text{ cm Water}}{1 \text{ atm}} \cdot \frac{101.325 \text{ kPa}}{1 \text{ atm}} \cdot \frac{1 \text{ psi}}{6.895 \text{ kPa}} = 0.711 \text{ psi}$$

$$50 \text{ cm Water} \cdot \frac{1033 \text{ cm Water}}{1 \text{ atm}} \cdot \frac{76 \text{ cm Hg}}{1 \text{ atm}} \cdot \frac{1 \text{ in}}{2.54 \text{ cm}} = 1.45 \text{ in of Hg}$$

## 1

## Introduction to Materials Science and Engineering

- 1-4 Steel is often coated with a thin layer of zinc if it is to be used outside. What characteristics do you think the zinc provides to this coated, or galvanized, steel? What precautions should be considered in producing this product? How will the recyclability of the product be affected?

**Solution:** The zinc provides corrosion resistance to the iron in two ways. If the iron is completely coated with zinc, the zinc provides a barrier between the iron and the surrounding environment, therefore protecting the underlying iron. If the zinc coating is scratched to expose the iron, the zinc continues to protect the iron because the zinc corrodes preferentially to the iron (see Chapter 23). To be effective, the zinc should bond well to the iron so that it does not permit reactions to occur at the interface with the iron and so that the zinc remains intact during any forming of the galvanized material. When the material is recycled, the zinc will be lost by oxidation and vaporization, often producing a "zinc dust" that may pose an environmental hazard. Special equipment may be required to collect and either recycle or dispose of the zinc dust.

- 1-5 We would like to produce a transparent canopy for an aircraft. If we were to use a ceramic (that is, traditional window glass) canopy, rocks or birds might cause it to shatter. Design a material that would minimize damage or at least keep the canopy from breaking into pieces.

**Solution:** We might sandwich a thin sheet of a transparent polymer between two layers of the glass. This approach, used for windshields of automobiles, will prevent the "safety" glass from completely disintegrating when it

## CHAPTER 5

## Factorial Experiments

## CHAPTER OUTLINE

5.1 BASIC DEFINITIONS AND PRINCIPLES

5.2 THE ADVANTAGE OF FACTORIALS

5.3 THE TWO-FACTOR FACTORIAL DESIGN

5.3.1 An Example

5.3.2 Statistical Analysis of the Fixed Effects Model

5.3.3 Model Adequacy Checking

5.3.4 Estimating the Model Parameters

5.3.5 Choice of Sample Size

5.3.6 The Assumption of No Interaction in a Two-Factor Model

5.3.7 One Observation per Cell

5.4 THE GENERAL FACTORIAL DESIGN

5.5 FITTING RESPONSE CURVES AND SURFACES

5.6 BLOCKING IN A FACTORIAL DESIGN

SUPPLEMENTAL MATERIAL FOR CHAPTER 5

S5.1 Expected Mean Squares in the Two-Factor Factorial

S5.2 The Definition of Interaction

S5.3 Estimable Functions in the Two-Factor Factorial Model

S5.4 Regression Model Formulation of the Two-Factor Factorial

S5.5 Model Hierarchy

The supplemental material is on the textbook website [www.wiley.com/go/global/montgomery](http://www.wiley.com/go/global/montgomery).





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