Physical Science

A problem solving approach

CALIFORNIA STATE SERIES

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preface

The methods of teaching science have undergone a great deal of careful study, evaluation, and change in recent years. One of the most fundamental changes that has taken place is the increased emphasis upon student involvement in the learning process. This means that the student must be a participant in the discovery of science concepts rather than merely a receiver of information. This movement has been spearheaded on the secondary level, especially by courses designed to prepare students for college science programs. The elementary school science curriculum has also been made more meaningful by the development of a number of fine programs that encourage participation by the learners.

Recognizing the need for a similar reevaluation and restructuring of the science curriculum at the intermediate level, the authors have developed a two-year, activity-oriented science program. The program, which is non-sequential, is designed to offer a working experience in science at the intermediate level for students with a wide range of interests and abilities.

The authors realize that the learner must be involved in the learning process if an activity is to have meaning. With this fact in mind, learning experiences have been designed that are interesting to the student and at the same time teach the concepts essential to a sound understanding and background in science. In the two books in this series—*Physical Science: A Problem Solving Approach* and *Life Science: A Problem Solving Approach*—*telling* is kept to a minimum; the emphasis is on *doing*. No attempt has been made to provide an all-inclusive collection of scientific facts and terms. Rather, several important concepts are introduced and developed in each course.

It is the hope of the authors that by the end of this course each student will have:

1. gained a better understanding, through the discovery method, of physical and natural laws and concepts;

2. come to appreciate the need to make accurate observations;
3. learned to keep neat, well-organized records;
4. learned to recognize and distinguish between observations and interpretations;
5. come to appreciate the importance of science and technology in today's world.

This book is organized into four units: Principles of Measurement, Force and Motion, Forms of Energy, and Chemistry of Matter. Each unit is divided into several chapters, which consist mainly of problems or investigations. There is a brief introduction to each unit giving the student a overview of the contents of the unit. Each chapter includes only as much informative reading material as is necessary to assist the student in solving the problems that follow. Connecting information is used to provide a logical transition from one problem to the next.

In using this material, students are given maximum opportunity for direct participation in discovering and developing many basic concepts of physical science. To facilitate this approach to learning science, the reading material (text) and lab manual have been combined into one book. The book is intended to be used in a laboratory-oriented science course.

The authors of this text have all been involved in teaching laboratory-oriented science courses. Preliminary versions of this course have been field tested with several thousand students in the Anaheim Union High School District. Feedback of information from this field testing program was collected and subjected to critical examination and evaluation, which, in turn, was followed by extensive editing and rewriting.

The authors would like to thank the Anaheim Union School District and the many teachers who used the preliminary materials. Their cooperation and suggestions helped immensely in making the corrections and improvements that are contained in this final version of the program.

to the student

Space travel, laser communication, atomic research, and undersea exploration are but a few examples of the exciting activities in which scientists are engaged. The world around you is an interesting and exciting place. Why has our present generation been able to make such spectacular advances in science and technology? In part, because man has a better understanding of the natural laws and forces that govern the universe. Man has gained this understanding through the constant questioning of *how* and *why* things behave as they do.

There are many different ways to go about learning science. You may read books, watch films, listen to lectures, and define vocabulary terms. Such activities as these are useful, but they are also limited, because they are the thoughts and experiences of someone else. This course, **Physical Science: A Problem Solving Approach,** is written to modify this and provide you with an opportunity to use the laboratory method of solving problems.

The heart of this program is the work *you* do in the laboratory. Instead of just reading or listening for correct answers to problems, you will be given the chance to perform many different experiments to help you solve these problems. We believe this learning experience will prove to be the most fascinating and rewarding you have ever had.

For many of you this will be your first chance to set up and carry out an experiment of any kind. This course is divided into four units, each consisting of several chapters. Each chapter begins with some background information to start you thinking, followed by a number of related problems, and ending with review questions.

It is most important that you know what you are to do before attempting to solve the problem. Do not be afraid to ask for help, but first be sure you have carefully read the procedure. Your teacher will show you how to use equipment with which you are not familiar. None of the equipment or chemicals you will be asked to use are considered hazardous when used according to directions.

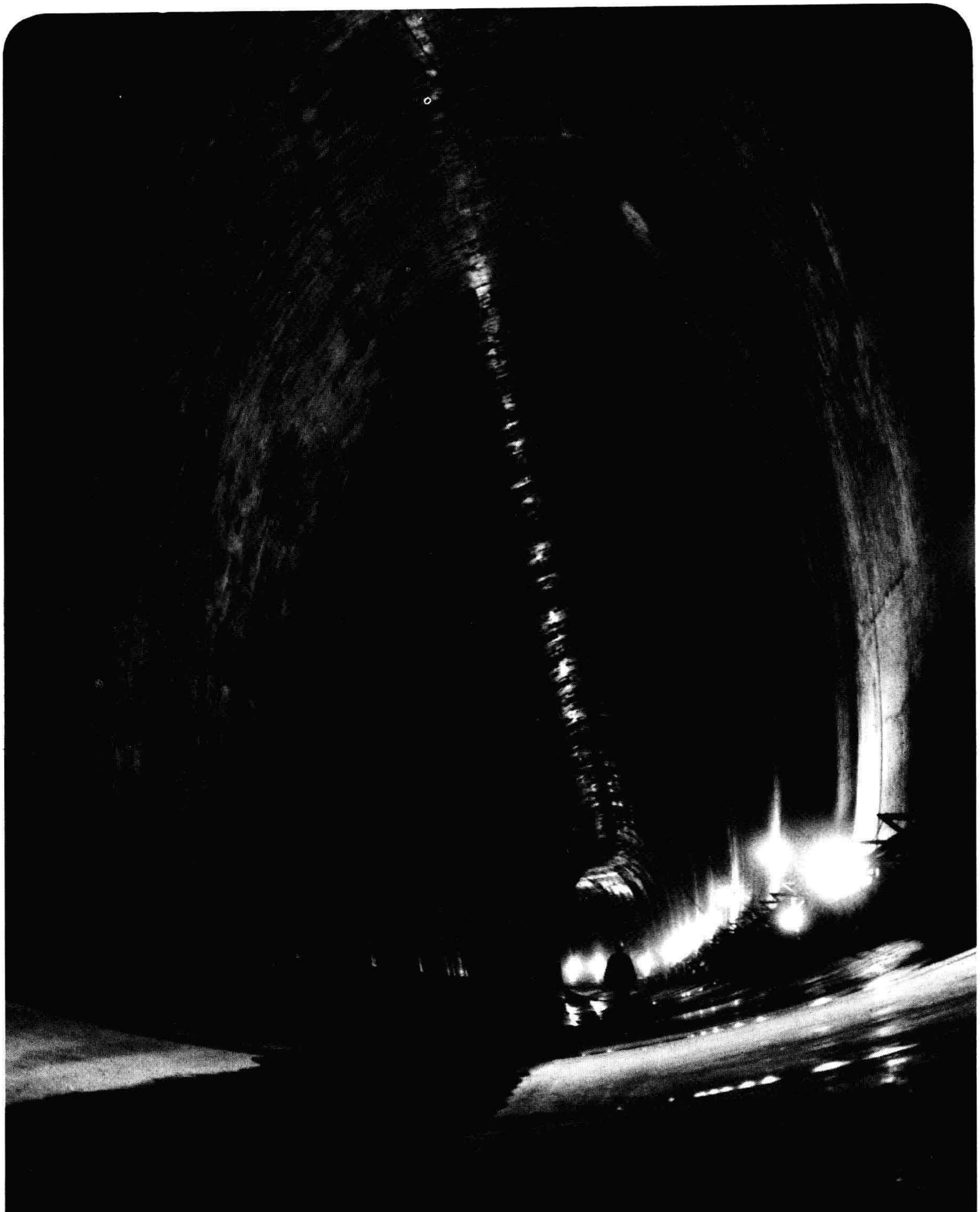
Each problem starts as a question, followed by a statement of purpose, a list of materials used, and a procedure. A number of questions are asked throughout the procedure that will guide you to the solution of the original problem. You should try to answer guide questions as you go along, while you remember exactly what happened. You may not be sure of the answers to some guide questions. Do not be afraid to write down what you think is the best answer to a question, but always be prepared to explain any statement you make. At the end of each problem, you will find a summary of what you should have learned by doing the work in the problem.

You will probably be required to keep a record of your work in this course. This procedure is followed so that you will have all of your experimental data and calculations and your results and observations available for future study when you need them.

When working in a laboratory, safety becomes a very important consideration. The following is a list of general rules that must be kept in mind.

1. Follow directions exactly as written, unless these directions are modified by your teacher.
2. Unauthorized experimentation will not be tolerated. Perform *only* those experiments specifically designated or approved by your teacher.
3. Take care to protect your clothing; wear an apron when directed by your teacher.
4. Wear safety glasses when directed by your teacher.
5. Keep your work area clean and well organized.
6. In case of an accident, report to your teacher at once.

At the end of this course you will not be a master scientist. However, throughout the course you will gain experience in setting up problems, making observations, analyzing and interpreting facts, and reaching conclusions. Events in nature will become less mysterious and magical, and more organized and meaningful. The completion of this course should be only the beginning of your search for a better understanding of the world around you.

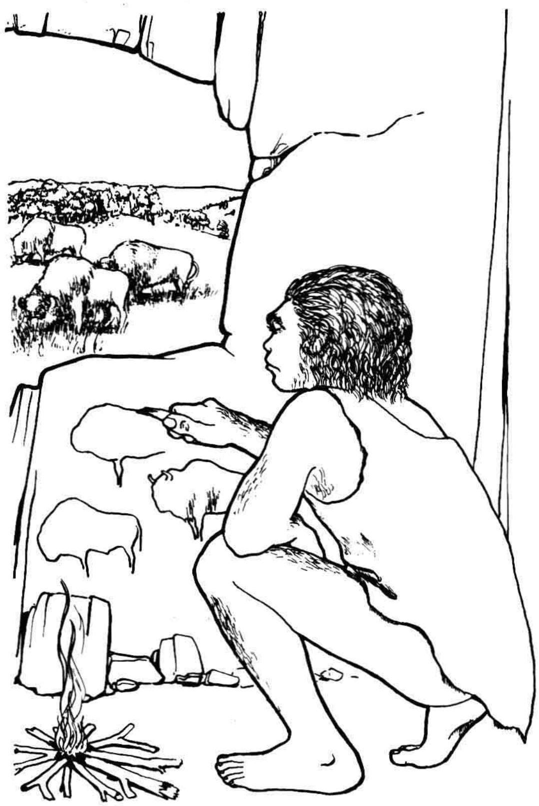


contents

unit 1
principles of measurement

Science is sometimes described as man's attempt to understand and explain what he observes through his senses. One of the first steps in any scientific activity is careful observation. Our curiosity about what we observe may lead us to ask What happened? or Why did it happen? Seeking answers to questions through careful work in the laboratory is an important job for both the scientist and science student.

Sometimes we may answer questions by making additional observations. We may ask such questions as: What color is it? How does it feel? Does it make a noise? Does it have an odor or taste? These questions may be answered by the use of one or more of our senses. But consider another type of question about an object: How big is it? How hot is it? How fast is it moving? You may be able to observe the object and get a general idea of its size, temperature or speed; but unless you can state your observations in terms that are meaningful to other persons, you cannot describe the object adequately.



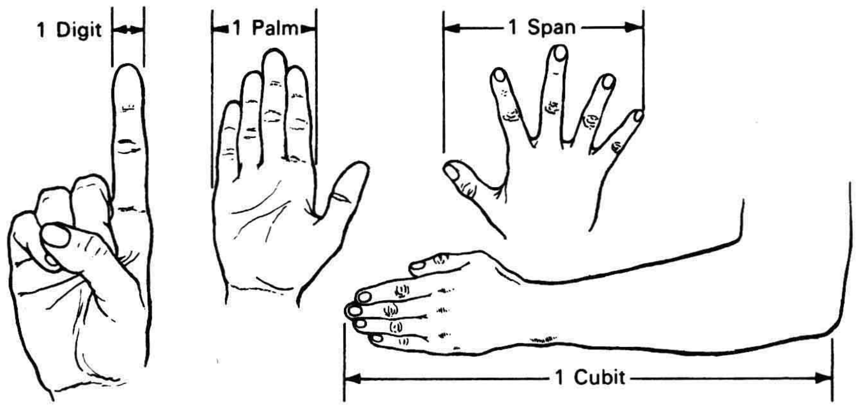
I-1. Primitive man probably had number sense.

Accurate observation and communication of ideas to others about what you have observed requires some standards of measuring. Before standards of measurement could be developed, some system of counting was necessary. Some ability to understand differences in number appears to be present in many animals. This ability has been called "number sense." If one of her kittens is removed, a mother cat will usually show that she is aware of the loss. It is reasonable to assume that early man had the ability to keep track of things by number sense.

Early Measurement Units

When man moved from caves into dwellings that he built for himself, there was a need for measurement during construction. Words were needed to express quantity, size, and distance. Eventually, by using the most convenient object in the environment, his body, man developed some common terms and definitions for units of measurement. These included the following measures:

Cubit: The distance from the point of the elbow to the tip of the middle finger

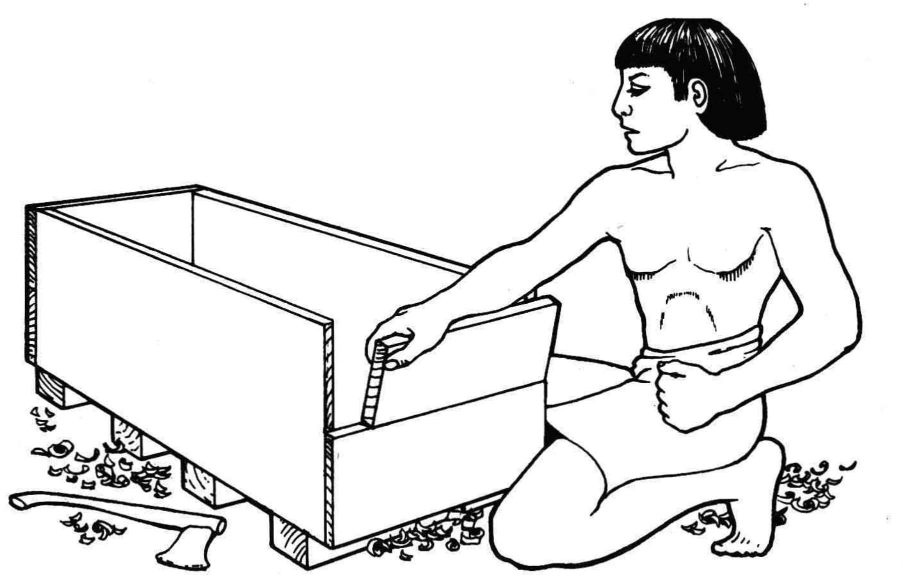


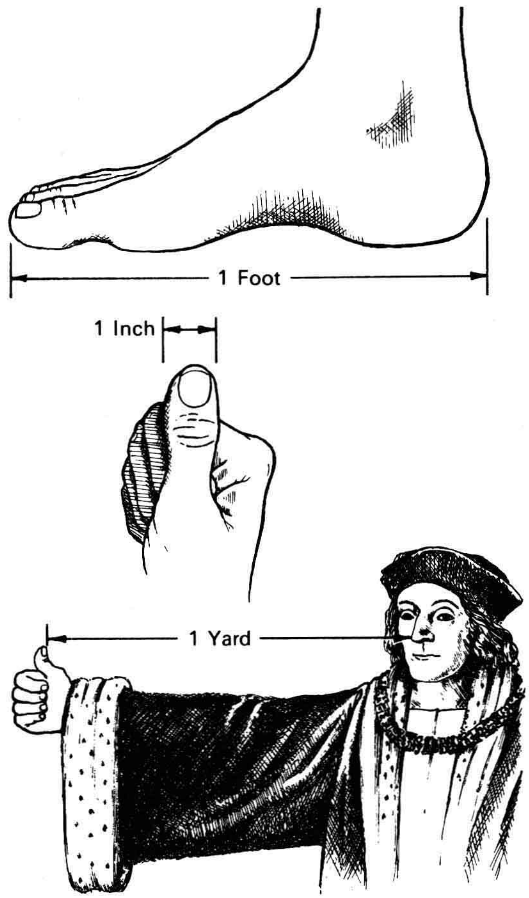
I-2. Early systems of measurement used parts of the body as units of measurement.

Span: The distance from the tip of the thumb to the tip of the little finger when the hand is spread out
Palm: The breadth of four fingers held together
Digit: The breadth of a finger

These units, particularly the cubit, were important to the early Babylonians, Hebrews, and Egyptians. If one person were doing all the measuring on a job, the cubit was always the same. When large temples or pyramids requiring the efforts of many men were being built, what kind of architecture would have resulted if each worker had measured with his own arms, hands, and fingers? The need for more precise, identical units of measure gave rise to one-cubit, two-cubit, and three-cubit measuring rods.

I-3. Units of measurement based on parts of the body could vary considerably from one person to another.



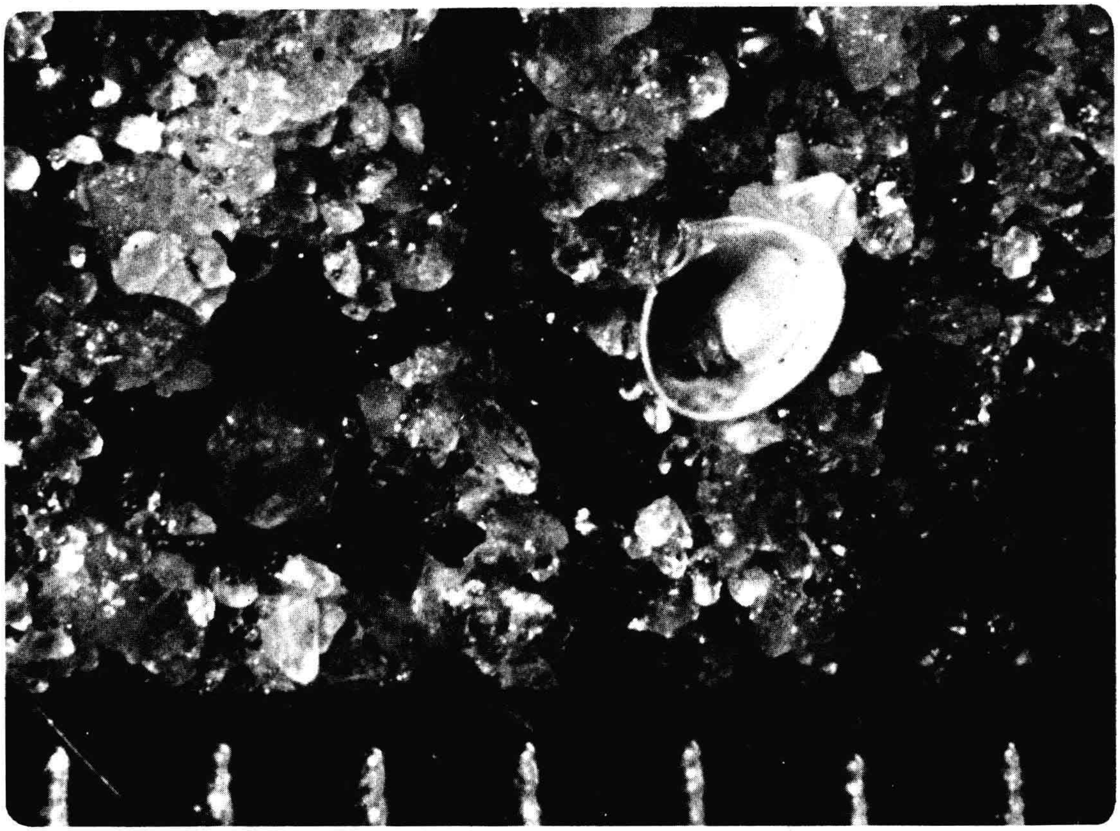


I-4. The names given to some early units of measurement are still in use today.

More Recent Measuring Units

The Romans gave us several units of measure you will recognize. The *mile* was one thousand paces, the *foot* was the length of a man's foot, and the *inch* was the breadth of a thumb. Henry I of England defined the *yard* as the distance from the tip of his nose to the end of his thumb when his arm was extended to one side. Stones were used in weighing with crude balances. The term *stone,* which equals 14 pounds, is still used in England today as a unit of weight.

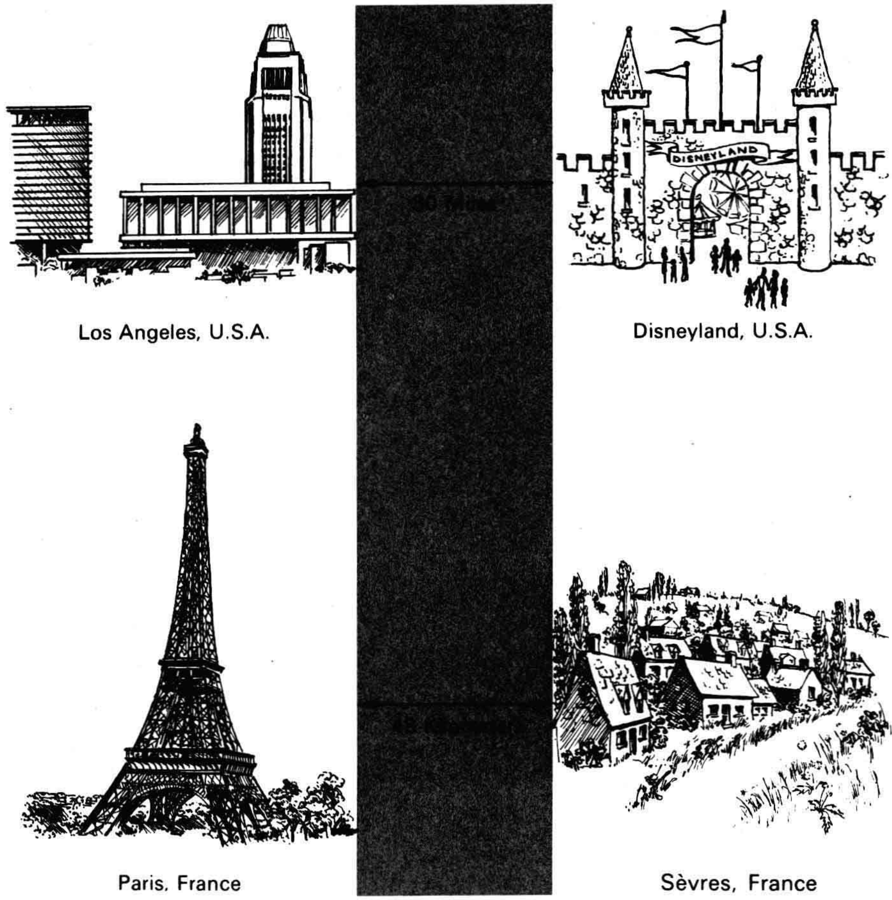
In this course, you will use the metric system of measurement. You will use the *meter* for measuring length, the *liter* for measuring capacity, and the *gram* for measuring mass. As measuring devices you will use the meter stick, the graduated cylinder, and the balance. You will be able to convert from one metric unit to another. You will learn about the importance of accuracy in measurement. In short, you will learn to make measurements of length, area, volume, and mass in units that would be understood by science students the world over.



chapter 1 measuring length, area, and mass in the metric system

Whenever you want to describe how long, how heavy, how big, or how far something or some place is, you make measurements. Not everyone, however, uses the same units to express these measurements. If you were asked how far it is from your city to the next city north, you would probably answer in miles. The mile is a unit of distance in the English system. If a person in France, Spain, or Mexico were asked the same question, he would give his answer in kilometers. A kilometer is a unit of distance in the metric system.

To get a better idea of the relationship between the mile and the kilometer, we can compare equal distances in the English and the metric systems. The distance from Los Angeles, U.S.A. to Disneyland, U.S.A. is 30 miles. An equal distance in France, from Paris to Sèvres, is

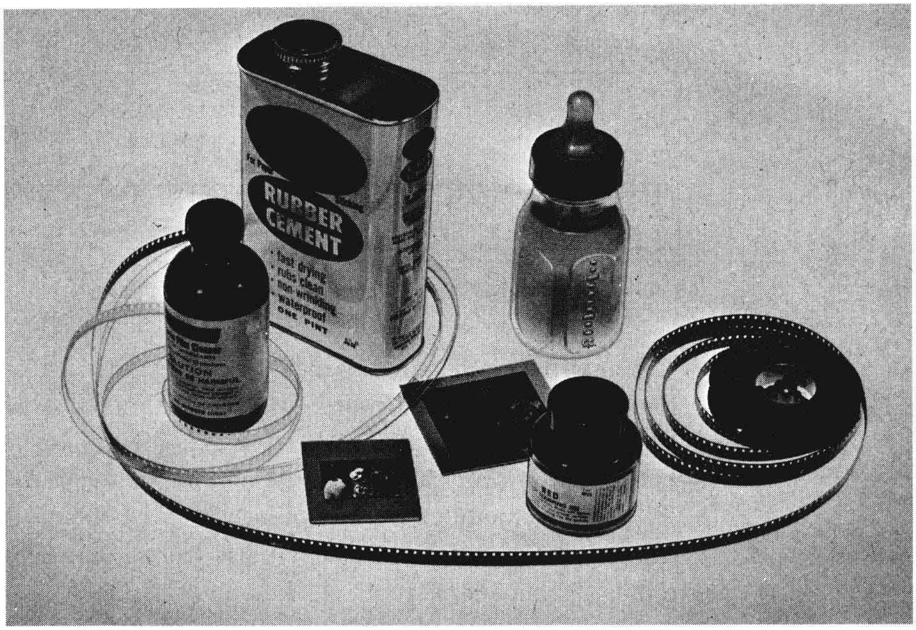


1-1. Two equal distances expressed in units of two different systems of measurement.

48 kilometers. If 30 miles equals 48 kilometers, then one mile equals 1.6 kilometers.

Units of measure sometimes have little apparent relationship to other units of measure in the same system. This is true in the English system of measurement. If you want to change a length in inches to its equal length in feet, you divide by twelve, the number of inches in one foot. If you want to change a length in feet into yards, you divide by three, the number of feet in a yard. From these examples you can see that the relationship between different units of length in the English system of measurement is not consistent.

On the other hand, the money system used in the United States is a model of simplicity. If you need to change a number of pennies into dimes, you divide by the number of pennies in one dime, ten. To change dimes into dollars, you again divide by ten, the number of dimes in one dollar. It is easy to change from one unit into another in the U.S. money system because all relationships between units in the system are based on multiples of ten.



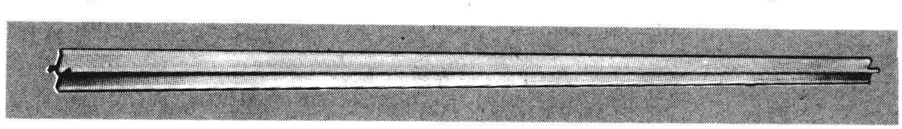
1-2. Many familiar objects are described in metric units.

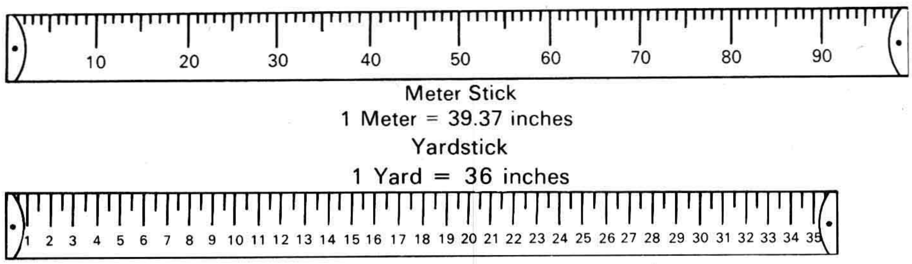
The Metric System

The **metric system** is a system of measurement that uses units based on multiples of ten. You have already heard of many things that are measured in metric units. Home movie film is 8 millimeters wide, and slide film is 35 millimeters wide. Medicine bottles are often graduated in cubic centimeters as well as ounces. The net weight of packaged food is listed in grams as well as ounces.

The metric system gets its name from the basic unit of length, the **meter.** A meter was originally defined in 1791 as one ten-millionth of the distance from the equator to the North Pole. According to this definition, the distance from the North Pole to the equator would be ten million meters. Later, the meter was defined as the distance between two scratches on a platinum-iridium bar. This metal bar, known as the standard meter, is carefully preserved in a laboratory in Sèvres, France. In 1960, the meter was again redefined in terms of an exact number of wavelengths of a pure color of light given off by the element krypton-86. The meter was redefined in this precise way so that the length standard could be measured with extreme accuracy any place in the world without direct comparison with the standard meter in Sèvres.

1-3. This platinum-iridium meter bar is kept at the National Bureau of Standards in Washington, D.C. It is an accurate copy of the standard meter bar kept in France.





1-4. One meter is a few inches longer than one yard.

You will soon be making measurements with a stick that is one meter long. This is called a meter stick. One meter is a few inches longer than one yard. Your meter stick is equal in length to the distance between the scratches engraved on the standard meter bar at Sèvres.

Do you remember we mentioned Sèvres as being located in the same distance from Paris as Disneyland is from Los Angeles? We said that either distance was about 48 kilometers. Does the word "kilometer" suggest that it has something to do with length measurement in meters? If you knew what the prefix "kilo" meant, you would know how many meters there are in a kilometer. Another metric unit mentioned before was the millimeter. If you knew what the prefix "milli" meant, you would know how many millimeters there are in a meter. Table 1-1 lists the prefixes used in the metric system.

Now let us see how you would use these prefixes to change from one length to another in the metric system. You should form the habit of working out all examples that are given here on a piece of scratch paper. This will help you to understand the process more quickly.

Let us use that distance measurement between Los Angeles and Disneyland again. It is given as 30 miles or about 48 kilometers. Looking at Table 1-1, we see that a **kilometer** is 1,000 times the basic unit, the meter. Therefore, 48 kilometers equal 48,000 meters. Try another conversion problem. A desk measures 65 centimeters across. How many meters does it measure? Table 1-1 indicates that centimeters are 1/100 as large as the basic unit, the meter. This means that there are 1/100 as many meters as centimeters in the width measurement of the desk.

$$\frac{1}{100} \times 65 = \frac{65}{100} = 0.65 \text{ meters}$$

Do you notice that the numbers, or **digits**, that we got for the width in meters are the same as the original measurement in centimeters? The only thing changed is the location of the decimal point. This is true for all changes within the metric system. Your only problem will be to