**Chapter 1: Measurement**

Measurement is widely used in business and industry, in science and technology, in manufacturing and engineering, as well as in many aspects of daily living.

Measurement gives a number to a particular characteristic of a person, an object or a concept. When measurements are made, they are expressed quantitatively as numbers. This, therefore, entails the study of the standard u8nits of measure and the proficient use of measuring devices.

Ancient people made use of counting to measure objects and distances. Now, modern technology makes possible the use of measuring devices such as counters, scales, meters, transits, spectroscopes, and the like.

**1.1: The History of Measurement**

The idea of measurement dates back to the ancient civilizations of Egypt, Babylonia and China. Through trade and conquest, systems of measurements spread to other parts of the world.

**The Ancient System**

The ancient system of measurement makes use of body parts.  
The basic units used by the early Egyptians are:

*Cubit:* the length of the distance from the elbow to the extend fingertip  
*Digit:* the subdivisions of the cubit, supposed to be a finger’s breadth  
*Small span/large span:* the length of the distance covered with the palms of the hand.

The basic unit used by the early Babylonians is:

*Mina: the earliest known unit of weight.*

The basic units used by the early Greeks are:

*Finger:* the basic unit of length  
*Olympic cubit:* the equivalent of twenty four fingers  
*Talent:* the basic unit of weight  
*Metrites:* the basic unit of liquid measure

The Chinese system of measurement employed parts of the body, such as the distance from the pulse to the base of the thumb.

*Shih/Tan:* the basic units of weight  
*Chih/Chang:*  the basic units of length

The standard measure for grain included its *weight* and its *pitch* when struck. This gives the reason why the inclusion of the acoustic dimension is its unique characteristic. Another characteristic of the Chinese measure is the use of the *decimal notation.*

**The Medieval System**

The medieval system of measurement was an offshoot of the Roman system which was a mixture of the Babylonian, the Egyptian and the Chinese systems.

*Libra:* the medieval unit of weight  
*Roman mile:* the unit of measure for distance with varying number of feet and yards.  
*pinte:* the basic unit of liquid measure  
*quart:* the unit of dry measure similar to the modern English quart.

**The English System**

The English system used by Great Britain and its colonies:  
 *inch:* length of 3 barley corns  
 *foot:* length equivalent to 12 inches  
 *yard:* the standard unit of length divided into 3 feet  
 *perch:*  equivalent to 5.5 yards  
 *acre:* 4 rods wide by 40 rods long  
 *furlong:*  standardized as one-eighth of a mile  
 *English Pound:*  a troy weight  
 *avoirdupois:*  used for goods that had to be weighed  
 stone: a multiple of the English pound

**The Metric System**

The metric system came about as a result of the French Revolution. By 1799, a new law in France defined the standard units of measure.

*Meter:* for length  
 *gram:* for weight  
 *liter:* for liquid volume  
 *are:* for area  
 *stere:*  for volume

**The International System**

The *Systeme International d’ Unites* (SI) was extablished in October 1960 by the 11th General Conference on Weights and Measures in Paris.  
 *meter:  
 kilogram:  
 second:  
 ampere:*

**1.2: Measures and Measuring Devices**

The results of measuring are merely near approximations since measurements a re not always exact. There is often a relative error involved.  
 Accuracy of measurements depends on two factors:  
 1. The skill of the person doing the measuring; and  
 2. The precision of the instrument used in measuring.  
 The first factor can easily be developed through constant practice while the second factor is totally dependent upon the measuring device.  
 As noted from the development of measurements as well as observed from daily life activities, different quantities require different units of measure and different measuring devices.  
 Originally, our forefathers made use of their body parts to measure lengths and distances. Unfortunately, these nonstandard units proved inconvenient, paving the way for standardized units like the metric system or *Systeme International d’ Unites* (SI). This system of measurement is the one commonly used by most countries today.

**1.2.1: Measure of Length**

The fundamental unit of length in the metric system is the *meter*. It is a decimal system for measurement where multiples and fractions of the basic unit(meter) correspond to powers of ten.

**TEST YOURSELF  
 Choose the most realistic unit of measure for each.**

1. Length of a ballpen
2. Width of a blackboard
3. Thickness of a notebook
4. Length of a pair of pants
5. Height of a tree
6. Height of a 12 year old boy
7. Length of a curtain material
8. Width of a street
9. Diameter of a 5c coin
10. Thickness of a glass

**Convert the following. (Use the metric converter.)**

1. 2km to m = **2000 m**
2. 354 cm to m = **3.54 m**
3. 7.15 m to cm = **715 cm**
4. 275 dm to m = **27.5 m**
5. 80 mm to m = **0.08 m**
6. 2650 m to km = **2.65 km**
7. 0.09 m to mm = **90 mm**
8. 8.75 m to km = **0.00875 km**
9. 60.8 km to m = **60,800 m**
10. 4585 cm to m = **45.85 m**

**PROBLEMS**

1. **A boy ran a distance of 5.8 kilometers . How many meters did he run?**
   1. **5.8 x 1000 = 5,800 meters**
2. **A car traveled a distance of 23.6 kilometers. How many meters did the car travel?**
   1. **23.6 x 1000 = 23,600 meters**
3. **A piece of wood is 470 centimeters long. How long is it in meters?**
   1. **470 x 0.01 = 4.7 meters**
4. **Loida walked 204 meters to her classmate’s house and together they walked 523 meters to school. How many kilometers was covered by Loida alone?**
   1. **204 x 0.001 = 0.204 kilometers**
5. **Ben traveled a distance of 126 kilometers in 2 ½ hours. How many meters did Ben travel? How many minutes did it take him to travel 126 kilometers?**
   1. **126 x 1000 = 126,000 meters.**
   2. **(2 x 60) + (60/2) = 120 + 30 = 150 minutes.**
6. **Jose walks 378 meters while Rene walks 0.67 kilometer. What is the difference between the distances they walked in centimeters?**
   1. **((0.67 x 1000) - 378) x 100 = (670 - 378) x 100 = 29,200 centimeters**
7. **A book is 48 millimeters thick. How thick is the book in centimeters?**
   1. **48 x 0.1 = 4.8 centimeters.**
8. **Luisa needs 2.3 meters of cloth for her project. How many decimeters of cloth does she need?**
   1. **2.3 x 10 = 23 decimeters.**

**1.2.2: Measure of Area**

The metric system uses the *square meter* (m2) as the unit of area. A square meter is a square 1 meter long on each side.

A *square centimeter*, which is a square 1 cm long on each side, is used to measure smaller areas like a piece of pad paper, a photograph, or the surface of a desk.

A *square millimeter,* which is a square 1 mm long on each side, is used to measure microscopic objects like those on a microscope side.

The area of a square 10 m on each side is called an *are* which is used to measure garden plots or building lots. An area equivalent to 100 ares is called a *hectare* which is used to measure big farms and ranches. Very large-areas, like areas of cities and states, are reported in *square kilometers.*

**TEST YOURSELF**

**Answer the following.**

1. **How many square meters are in one square kilometer?**
   1. **1x1000 = 1,000 m2**
2. **A square meter is equivalent to how many square millimeters?**
   1. **1x1000 = 1,000 mm2**
3. **What is common name for dam2? hm2?**
4. **How many decimal places to the right do we move to change km2 to m2?**
   1. **3 decimal places**
5. **How many square meters are in one hectare?**
   1. **1x100 = 100 m2**

**Choose the most realistic unit of measure of area for each.**

1. **The area of the front cover of a book**
2. **The total area of a big estate/farm**
3. **The floor area of a small house**
4. **The surface area of a microchip**
5. **The surface area of a blackboard**

**Convert the following. (Use the metric converter.)**

1. **0.05cm2 to mm2**
   1. **0.5 mm2**
2. **1.87m2 to cm2**
   1. **187 cm2**
3. **610 dam2 to km2**
   1. **610x0.01 = 6.1 km2**
4. **0.398 km2 to m2**
   1. **398 m2**
5. **7510 mm2 to m2**
   1. **7.51 m2**
6. **1124 mm2 to cm2**
   1. **112.4 cm2**
7. **0.0014 km2 to ha**
   1. **0.014 ha**
8. **9625 m2 to ha**
   1. **96.25 m2**
9. **215 a to ha**
   1. **21.5 ha**
10. **7.4 ha to m2**
    1. **740 m2**

**PROBLEMS**

**Solve the problems**

1. **A man is buying a lot while measures 8760 square meters. How many hectares of land is he buying?**
   1. **87.6 ha**
2. **Mrs. Reyes is selling a piece of land which measures 3.81 hectares. If the selling price is P2,500 per square meter, how much will she receive from the sale of her land?**
   1. **(3.81 x 100) x 2,500 = P952,500**
3. **If 3,748 areas of land is divided into four equal parts, how many square meters will each part be?**
   1. **(3,748 / 4) x 10 = 9,370 m2**
4. **A piece of cardboard measures 64 cm by 48 cm. What is its area in square meters?**
   1. **(64 cm x 48 cm) x 0.01 = 30.72 m2**
5. **If the area of a rectangular garden lot is 144 m2, how many square decimeters of grass are needed to fill it?**
   1. **1,440 dm2**
6. **How many square meters of wall paper are needed to cover the walls of a room 12 m by 4 m?**
   1. **48 m2**

**1.2.3 Measure of Volume and Capacity**

The metric system uses the liter (L) as the fundamental unit of volume. It represents the volume of a cube that measures 10 cm or 1 dm on each edge.

Very small volumes are measured in milliliters, like liquid medicine in milliliter bottles. Large are measured in cubic meters (m3), like water in tanks, reservoirs or swimming pools.

A liter cube can be filled with a 10 x 10 array of centimeter cubes to cover its bottom, and 10 layers of this array can fill the liter cube to the top. Thus, 1 liter or 1 cubic decimeter is equivalent to 1000 cm3.

**TEST YOURSELF**

**Choose the most realistic unit of measure of volume/capacity.**

1. **A bucket of water**
2. **A can of soda**
3. **A tablespoon of sugar**
4. **A cup of coffee**
5. **A glass of juice**
6. **A can of gasoline**

**Convert the following. (Use the metric converter.)**

1. **120 cm3 to m3**
   1. **1.2 m3**
2. **77 m3 to cm3**
   1. **7,700 cm3**
3. **622 cm3 to m3**
   1. **6.22 m3**
4. **3.7 m3 to L**
   1. **37 L**
5. **0.003 m3 to cm3**
   1. **0.3 cm3**
6. **2.3 L to m3**
   1. **0.23 m3**
7. **0.15 km3 to m3**
   1. **0.00015 m3**
8. **830 m3 to km3**
   1. **0.83 km3**
9. **578 cm3 to m3**
   1. **5.78 m3**
10. **6.4 m3 to L**
    1. **64 L**

**PROBLEMS**

**Solve the problems.**

1. **A boy fills a drum with 375 cubic decimeters of water. How many cubic meters of water is in the drum?**
   1. **37.5 dm3**
2. **A basin contains 670 cubic millimeters of water. How many liters of water is in the basin?**
   1. **6.7 L**
3. **A tank contains 15.6 liters of gasoline. How many cubic meters of gasoline is in the tank?**
   1. **1.56 m3**
4. **Which is the most realistic measure of volume for a bottle of soda: 473 mL, 473 cL, or 473 L?**
5. **A tablespoon of syrup is about 15 mL. What part of a liter can a tablespoon hold?**
   1. **1.5 L**

**1.2.4 Measure of Mass**

The mass of an object is the amount of matter it contains. The basic unit of mass in the metric system is the *kilogram*(kg). A kilogram is the weight of 1 liter of water in its densest state. A milliliter of water weighs 1/1000 of a kilogram, which is called a *gram* (g).

Thus, 1000 grams is equivalent to 1 kilogram. Grams is used for small weights such as ingredients in recipes or nutritional contents of various foods. Remember also the meaning of the prefixes in connection with the measures of mass, such as milligram, centigram, decigram, dekagram, hectogram, and kilogram.

A *platform* balance is an instrument used in measuring the mass of small objects. It is usually accurate to the nearest 0.01 gram. Before using the platform balance, it is important to make sure that the instrument is clean and dry, with the pointer at its position of rest. The object to be weighed is placed on one pan and the standard mass on the other. Keep on adding or removing the standard mass until the 2 pans are balanced and the pointer is at its position of rest.

A weighing scale for commercial use is more convenient and easier to manipulate, but not as accurate. The object to be weighed is placed on a pan and the pointer of the instrument moves through the unit divisions to the point which indicates the weight of the object.

**TEST YOURSELF**

**Choose the most realistic unit of mass for each of the following.**

1. **A pencil**
2. **A baby**
3. **A pail of water**
4. **A teaspoon of salt**
5. **A glass of milk**
6. **A tablespoon of flour**
7. **A basketball**
8. **A car**
9. **A piece of pad paper**
10. **A paper clip**

**Convert the following measure of mass.**

1. **8 kg to g**
2. **2.5 kg to g**
3. **850 mg to g**
4. **370 cg to mg**
5. **75 dg to mg**
6. **3000 g to kg**

**PROBLEMS**

**Solve the problems.**

1. **The mass of one sachet of coffee is 0.005 kilograms. What is its equivalent net weight in grams?**
2. **The content of one bag of powdered juice is 750 grams. How many kilograms are in the bag?**
3. **A girl carries her schoolbag weighing 2.48 kilograms. How much weight in grams is she carrying?**
4. **A bridge can support a mass of 2.8 tonnes. How many kilograms can the bridge support?**
5. **A boy weighing 27.6 kilograms sits on one end of a seesaw. How many grams should another boy weigh if he is to balance the first boy on the opposite end?**
6. **The mass of a box of soap is 460 grams. What is the mass of the box of soap in kilograms? In milligrams?**

**1.2.5 Measure of Temperature**

**The degree *Celsius* is used to measure temperature. It is named after the Swedish astronomer, Anders Celsius, who devised the Celsius scale in 1742.**

**Original called centigrade, two reference temperatures are used:**

1. **The freezing point of water (0oC); and**
2. **The boiling point of water (100oC).**

**A metric thermometer used to measure temperature is divided in intervals between the freezing and boiling points.**

**Degree Celsius can be transformed into *degree Fahrenheit* (named after a German instrument maker, Gabriel Fahrenheit), the English equivalent of Celsius.**

**TEST YOURSELF**

**Convert the following to the nearest degree.**

1. **4oC to oF**
2. **34oC to oF**
3. **98.6oF to oC**
4. **80.5oF to oC**
5. **42oC to oF**
6. **68oF to oC**

**Choose the best approximation of temperature for the following.**

1. **A good day to go swimming: 15oC, 22oC, 80oC**
2. **A feverish condition: 29oC, 38oC, 66oC**
3. **A moderate oven temperature: 350oF, 400oF, 450oF**
4. **A glass of calamansi: 10oC, 5oC, 40oC**
5. **Normal body temperature: 10oC, 20oC, 37oC**
6. **Densest state of a liter of water: 4oC, 10oC, 15oC**

**1.2.6 Measure of Time**

Primitive men used to tell time by the position of the sun, the stars and the moon, and the behavior of animals. They used the sundial, the water-clocks and the hourglass for hundreds of years until invention of the mechanical clocks, the stately grandfather clocks, the quartz and digital watches, and more recently, the atomic clocks.

Time is measured by the rotation of the Earth on its axis (making one full day) and its complete revolution around the sun (making one year) in 365 ¼ days. This means that in the period it takes the Earth to circle the sun once, the Earth makes 365 ¼ turns on its axis. Four one-fourths make up a day (added to February) so that leap year occurs every four years.

**TEST YOURSELF**

**Convert the following**

1. **2h to min**
2. **15 min to s**
3. **5 yr to mo**
4. **500 min to h**
5. **7 da to h**
6. **40 yr to da**
7. **82 mo to yr**
8. **3.5 decades to mo**
9. **1 century to yr**
10. **6 yr to da**

**PROBLEMS**

**Solve the problems.**

1. **The amount of time between two given times is called the *elapsed time.* What is the elapsed time between 8:15 A.M and 5:00 P.M?**
2. **How many minutes have elapsed between 1:30 P.M. and 4:45 P.M?**
3. **The flight time from Manila to Zamboanga is 1 hour and 40 minutes. If the plane leaves Manila at 12:30 P.M., at what time will it arrive in Zamboanga?**
4. **If year 2000 was a leap year, when will the next leap year occur?**
5. **In what year will the Philippines celebrate the 120th anniversary of its independence?**
6. **As an incentive, a company offered a 91-day leave with pay to its outstanding employee. How many months of vacation is it?**

**1.2.7 Measure of an Angle**

The measure of an angle is the amount of opening between the sides of the angle. An angle with the greater opening has the greater measure. For example, the measure of /X is greater than the measure of /Y.

Angles are measured by means of a *protractor*. A protractor is a semicircular device marked off in units of degrees from 0 to 180. The unit used in measuring angles is called *degrees*.

**1.3 Measurements Involving Ratios**

There are measurements which show the relationship between two quantities. This relationship can be expressed in the form of a ratio.

**TEST YOURSELF**

**Express each statement as a ratio.**

1. **The walking rate of a boy is 4 kilometers in 1 ½ hours.**
2. **The rate of movement of a turtle is 20 meters in 60 minutes.**
3. **The amount of water taken in by a man in a day is 9 glasses.**
4. **Three meters of dress material cost P500.**
5. **The speed of a car is 210 kilometers in 3 hours.**
6. **The amount of gasoline consumed by a hired vehicle is 5 liters. It covered a distance of 250 kilometers.**
7. **To mix a pitcher of orange juice, Beth used 3 glasses of water to 1 glass of juice concentrate.**
8. **The number of eggs in a carton is 36**
9. **Paulo finished reading a 320-page book in 3 ½ weeks.**
10. **Of the 100 seeds planted, an agriculturist harvested 84 ears of corn.**

**1.4 Rounding Numbers**

*Rounding* is an approximation technique which replaces complicated numbers with simpler once. It is used to facilitate computation.

There are situations that call for a knowledge of rounding numbers, a skill needed to make reasonable estimates.

**TEST YOURSELF**

**Round to the indicated place.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Nearest Tenth** | **Nearest Hundredth** | **Nearest Thousandth** |
| 1. **6.27** |  |  |  |
| 1. **5.669** |  |  |  |
| 1. **72.65** |  |  |  |
| 1. **0.29** |  |  |  |
| 1. **1.15** |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Nearest Ten** | **Nearest Hundred** | **Nearest Thousand** |
| 1. **2794** |  |  |  |
| 1. **6250.6** |  |  |  |
| 1. **86 658** |  |  |  |
| 1. **4562** |  |  |  |
| 1. **943 850** |  |  |  |

**PROBLEMS**

1. **A trader took a 5-day trip. He drove the following number of kilometers: 220.7, 198.3, 115.5, 276.5 and 231.9. What is the average number of kilometers traveled each day rounded to the nearest whole number?**
2. **Aling Conching bought a charcoal stove to reduce enrgy cost. She paid P180 for the stove. For a month’s use, she bought 3 sacks of charcoal that cost P54.15 each. What was the total cost of the stove and the charcoal? Estimate to the nearest peso.**

**1.5 Problems on Measurement**

Knowledge of measurement and problem-solving strategies are necessary in solving routine and nonroutine word problems. Many problems can be solved using arithmetic algebraic processes. There are problems, however, that can be solved by simply drawing a diagram, making a table or by setting up an equation.

**PROBLEMS**

**Solve these problems on measurement.**

1. **The speed of a hiker averages 2 km per hour uphill and 6 km per hour downhill. What is his average speed for the entire trip?**
2. **If a computer technician earns P75 per hour and works 40 hours per week, what is his monthly pay (assuming that there 30 days in a month)?**
3. **Trisha is having a party. She estimates that a kilogram of coleslaw will feed 8 guests. How many kilograms of coleslaw will she need to feed 60 guests?**
4. **Calculate the angle formed by the hands of the clock at 3 o’clock, 5 o’clock and 11 o’clock.**
5. **A fish is 75 cm long. The head is as long as the tail. If the head were twice as long and the tail were its present length, the body would be 45 cm long. How long is each portion of the fish?**
6. **Two farmers always plant their mango trees in square arrays, like those illustrated. This year they planted 11 more mango trees in their square garden than last year. If the garden is still a square, how many mango trees are there in the garden this year?**

**CHAPTER SUMMARY**

1. Measurement arose from the early man’s need to count objects and to find lengths and distances. The earliest units used are parts of the human body: the finger, the hand, the cubit, the foot and the step. Through trade and commerce, forms of measurement spread to other parts of the world.
2. The basic units of measurement used by the early Babylonians, Greeks, Romans and Chinese were later standardized to customary units of measure, used by Great Britain and its American colonies. This uniform system of measurement is necessary for easy computation and articulation.
3. The metric system came about by the 18th century as a result of the French Revolution. In 1960, the Systeme International d’ Unites(SI) was established by the 11th General Conference on Weights and Measures in Paris.

**EVALUATE YOURSELF**

**Choose the most appropriate measure for the following:**

**Length:**

1. **A pencil**
2. **A flagpole**
3. **A highway**

**Mass:**

1. **A cup of sugar**
2. **A steel cabinet**
3. **A 7-year-old girl**

**Liquid measure:**

1. **A bottle of cola**
2. **A tank of gasoline**
3. **A dose of medicine**
4. **A jug of water**

**Estimate the temperature (o Celsius) for each.**

1. **A glass of fruit juice**
2. **A low-grade fever**
3. **Boiling point of water**
4. **Room temperature.**

**Convert the following to the indicated units.**

1. **8.2 ha to m2**
2. **0.43 m3 to L**
3. **0.06 km2 to ha**
4. **3625 g to kg**
5. **0.12 m2 to mm2**
6. **62 894 mg to g**
7. **5.6 ha to a**
8. **0.013 m3 to cm3**
9. **74 kg to t**
10. **3.4 L to mL**

**Solve the following problems. Round your answers to the nearest tenth.**

1. **How many meters of wood is needed to completely surround a square whose side is 0.427 meter?**
2. **A box is 162 millimeters long. How long is it in meters?**
3. **A boy lives 1.025 kilometers from school. How far is his house from the school in meters?**
4. **If the length of a stick is 0.624 meter, how long is it in centimeters?**
5. **A baby weighs 3.39 kilograms at birth. If the baby’s weight increases by 1.2 kilograms after two months, what is his weight in grams in two months time?**
6. **A tank contains 8 cubic meters of water. How many liters of water is in the tank?**
7. **How many minutes will it take a girl to finish her sewing if she is able to do this in 1 ¼ hours?**
8. **If 45.2 liters of gasoline is needed for a full tank, how many cubic centimeters of gasoline will completely fill up the same tank?**
9. **Rosa lives three times as far from school as Anna. If Rosa’s house is 4.726 kilometers away from school, how far is Anna’s house from school?**
10. **When 1 ray is drawn inside an angle, 3 angles are formed. How many angles are formed with 5 rays?**