GOVERNMENT OF TAMILNADU

STANDARD NINE

TERM - I

VOLUME 3

SCIENCE

Untouchability is Inhuman and a Crime

A publication under Free Textbook Programme of Government of Tamil Nadu

Department of School Education

UNIT 1

Measurement and Measuring Instruments

EJC4ZT

Learning Objectives

To get exposed to:

- the rules to be followed while expressing physical quantities in SI units
- the derived units
- the usage of scientific notations
- the three characteristics of measuring instruments
- the usage of vernier caliper and screw gauge for small measurements
- to try and find the weight of an object using a spring balance
- the importance of accurate measurements

Introduction

Measurement is the basis of all important scientific study. It plays an important role in our daily life also. When finding your height, buying milk for your family, timing the race completed by your friend and so on, you need to be able to make measurements. Measurement answers questions like, how long, how heavy and how fast? Measurement is the assignment of a number to a characteristic of an object or event which can be compared with other objects or events. It is defined as the determination of the size or magnitude of something. In this lesson you will learn about units of measurements and the characteristics of measuring instruments.

1.1 Physical Quantities and Units

1.1.1 Physical quantities

Physical quantity is a quantity that can be measured. Physical quantities can be classified into two: fundamental quantities and derived quantities. Quantities which cannot be expressed in terms of any other physical quantities are called fundamental quantities. Example: Length, mass, time, temperature. Quantities like area, volume and density can be expressed in terms of some other quantities. They are called derived quantities.

Physical quantities have a numerical value (a number) and a unit of measurement (say, 3 kilogram). Suppose you are buying

3 kilograms of vegetable in a shop. Here, 3 is the numerical value and kilogram is the unit. Let us see about units now.

1.1.2 Unit

A unit is the standard quantity with which unknown quantities are compared. It is defined as a specific magnitude of a physical quantity that has been adopted by law or convention. For example, feet is the unit for measuring length. That means, 10 feet is equal to 10 times the definite predetermined length, called feet. Our forefathers used units like muzham, furlong (660 feet), mile (5280 feet) to measure length.

Many of the ancient systems of measurement were based on the dimensions of human body. As a result, unit of measurement varied from person to person and also from location to location. In earlier time, different unit systems were used by people from different countries. Some of the unit systems followed earlier are given below in Table 1.

Table - 1 Unit systems of earlier times

System	Length	Mass	Time
CGS	centimetre	gram	second
FPS	foot	pound	second
MKS	metre	kilogram	second

But, at the end of the Second World War there was a necessity to use worldwide system of measurement. Hence, SI (International System of Units) system of units was developed and recommended by General Conference on Weights and Measures in 1960 for international usage.

1.2 SI System of Units

SI system of units is the modernised and improved form of the previous system of units. It is accepted in almost all the countries of the world. It is based on a certain set of fundamental units from which derived units are obtained by multiplication or division. There are seven fundamental units in the SI system of units. They are also known as base units as in Table 2.

The units used to measure the fundamental quantities are called fundamental units and the units which are used to measure derived quantities are called derived units.

Table - 2 Fundamental physical quantities and their units

Fundamental quantities	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
Luminous intensity	candela	cd
Amount of substance	mole	mol

With the help of these seven fundamental units, units for other derived quantities are obtained and their units are given below in Table-3.

DO YOU KNOW?

Fortnight: A fortnight is two weeks or 14 days.

Moment: If you ask someone to wait for a moment, you know it is a short period of time. But, how short? It is 1/40 th of an hour or 1.5 minutes.

Table - 3 Derived quantities and their units

S.No	Physical quantity	Expression	Unit
1	Area	length × breadth	m^2
2	Volume	area × height	m^3
3	Density	mass/volume	Kgm^{-3}
4	Velocity	displacement/time	ms^{-1}
5	Momentum	mass × velocity	$kgms^{-1}$
6	Acceleration	velocity/time	ms^{-2}
7	Force	mass × acceleration	$kgms^{-2}$ or N
8	Pressure	force/area	Nm^{-2} or Pa
9	Energy (work)	force × distance	Nm or J
10	Surface tension	force/length	Nm^{-1}

Atomus: The smallest amount of time imaginable to us is a twinkling of the eye. This is called atomus. Do you know the value of this? It is 1/6.25 seconds or 160 milliseconds.

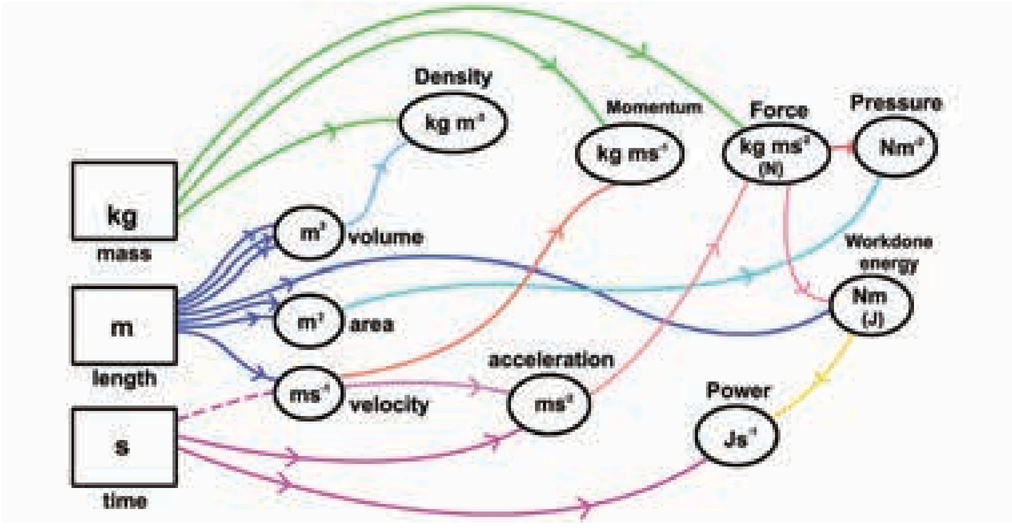
Donkey Power: You might have heard about horse power. But do you know donkey power? It is one third of a horse power. Its value is around 250 watt.

1.3 Fundamental Units of SI System

1.3.1 Length

Length is defined as the distance between two points. The SI unit of length is metre. One metre is the distance travelled by light through vacuum in 1/29,97,92,458 second.

In order to measure very large distance (distance of astronomical objects) we use the following units.



Flow chart for derived units

- Light year
- Astronomical unit
- Parsec

Light year: It is the distance travelled by light in one year in vacuum and it is equal to 9.46×10^{15} m.

DO YOU KNOW?

Light travels 3×10^8 m in one second or 3 lakhs kilometre in one second. In one year we have 365 days. The total number of seconds in one year is equal to $365 \times 24 \times 60 \times 60 = 3.153 \times 10^7$ second.

1 light year = $(3.153 \times 10^7) \times (3 \times 10^8) = 9.46 \times 10^{15}$ m.

Astronomical unit (AU): It is the mean distance of the centre of the Sun from the centre of the earth. 1 AU = 1.496×10^{11} m Figure 1.

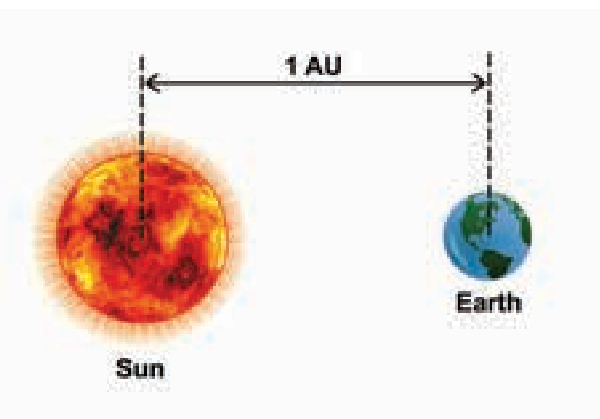


Figure 1 Astronomical unit

DO YOU KNOW?

1 AU is equal to 14,95,97,871 km or approximately equal to 150 million km or 1,500 lakhs km.

Parsec: Parsec is the unit of distance used to measure astronomical objects outside the solar system.

1 parsec = 3.26 light year.

DO YOU KNOW?

The nearest star alpha centauri is about 1.34 parsec from the sun. Most of the stars visible to the unaided eye in the night sky are within 500 parsec distance from the sun.

To measure small distances such as distance between two atoms in a molecule, the size of the nucleus and the wavelength, we use submultiples of ten. These quantities are measured in Angstrom unit (Table 4).

DO YOU KNOW?

The total length of all the blood vessels in human body is 96,000 km.

When born, a baby giraffe is 1.8 m (6ft) tall.

A chameleons tongue is twice the length of its body.

Info bits

In Tamil Nadu, people still use some common length scales other than SI units. It is advisable to know the relationship between SI units with these length scales.

One feet = 30.4 cm, one meter =3.2 feet.

One inch = 2.54 cm, one meter is approximately equal to 40 inches.

These length scales are still used in hardware shops to measure house hold things like pipes, wood. Carpenters still use inch scale.

1.3.2 Mass

Mass is the quantity of matter contained in a body. The SI unit of mass is kilogram. One kilogram is the mass of a particular international

Table - 4 Smaller and larger units

Smaller units	In metre	Larger units	In metre
Fermi (f) *	10^{-15} m	Kilometre (km)	10^{3} m
Angstrom (Å)**	10^{-10} m	Astronomical unit (AU)	1.496×10^{11} m
Nanometre (nm)	10^{-9} m	Light year (ly)	9.46×10^{15} m
Micron (micrometre μ m)	10^{-6} m	Parsec (pc)	3.08×10^{16} m
Millimetre (mm)	10^{-3} m		
Centimetre (cm)	10^{-2} m		

* unit outside SI system and not accepted for use with it
** Non-SI unit accepted for use with it.

prototype cylinder made of platinum-iridium alloy, kept at the International Bureau of Weights and Measures at Sevres, France.

The related units in submultiples of 10 (1/10) are gram and milligram and in multiples of 10 are quintal and metric tonne.

1 quintal = 100 kg

1 metric tonne = 1000 kg = 10 quintal

1 solar mass = 2×10^{30} kg

Atomic mass unit (amu):

Mass of a proton, neutron and electron can be determined using atomic mass unit.

1 amu = 1/12th of the mass of carbon-12 atom.

More to Know

SI unit of volume is m^3 or cubic metre. Volume can also be measured in (l).

1 l = $1 dm^3$ = 1000 ml

1ml = $1 cm^3$

Mass of 1 ml of water = 1g

Mass of 1l of water = 1kg

Mass of the other liquids vary with their density.

DO YOU KNOW?

1 TMC is (thousand million cubic feet) hundred crore cubic feet.

1 TMC = 2.83×10^{10} litre.

1 TMC is approximately 3000 crore litres.

1.3.3 Time

Time is a measure of duration of events and the intervals between them. The SI unit of time is second. One second is the time required for the light to propagate 29,97,92,458 metres through vacuum. It is also defined as 1/86, 400th part of a mean solar day. Larger unit for measuring time is millennium. 1 millenium = 3.16×10^{9} s.

DO YOU KNOW?

In villages, people still use different time scales other than SI time units.

One hour = 2.5 Nazhikai (நாழிகை)

One day = 60 Nazhikai, Day time = 30 Nazhikai and Night time =30 Nazhikai.

In day time nazhikai starts at 6 am and ends at evening 6pm. Total nazhikai in daytime= 12 hours × 2.5 Nazhikai = 30 Nazhikai. Similiarly in the night time the Nazhikai starts at 6 pm and ends next day at 6 am. Total nazhikai in night time =12 hours × 2.5 Nazhikai = 30 Nazhikai. For example, night 12 pm is equivalent to 15 Nazhikai (6 hours × 2.5 Nazhikai=15 nazhikai).

1.3.4 Temperature

Temperature is the measure of hotness. SI unit of temperature is kelvin(K). One kelvin is the fraction of 1/273.16 of the thermodynamic temperature of the triple point of water (The temperature at which saturated water vapour, pure water and melting ice are in equilibrium). Zero kelvin (0 K) is commonly known as absolute zero. The other units for measuring temperature are degree Celsius and Fahrenheit (Table 5). To convert temperature from one scale to another we use

$$C/100 = (F - 32)/180 = (K-273)/100$$

Example:

Convert (a) 300 K in to Celsius scale, (b) 104°F in to Celsius scale.

Solution

(a) Celsius = K-273 = 300-273 = 27°C

(b) Celsius = (F – 32) × 5/9 = (104-32) × 5/9 =72 × 5/9 = 40°C

1.4 Unit Prefixes

Unit prefixes are the symbols placed before the symbol of a unit to specify the order of magnitude of a quantity. They are useful to express very large or very small quantities. k(kilo) is the unit prefix in the unit, kilogram. A unit prefix stands for a specific positive or negative power of 10. k stands for 1000 or 10^3. Some unit prefixes are given in Table-6.

The physical quantities vary in different proportion like from 10^{-15} m being the diameter of nucleus to 10^{26} m being the distance between two stars and 9.11×10^{-31} kg being the electron mass to 2.2×10^{41} kg being the mass of the milky way galaxy.

Table – 6 Unit prefixes

Power of 10	Prefix	Symbol
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m

Contd. on next page

Table - 5 Temperature conversion table

Units	Fahrenheit	Celsius	Kelvin
Fahrenheit (°F)	F	(F – 32) × 5/9	(F – 32) × 5/9 + 273
Celsius (°C)	(C × 9/5) + 32	C	C + 273
Kelvin (K)	(K – 273) × 9/5 + 32	K-273	K

Table – 6 Unit prefixes (*Contd*)

Power of 10	Prefix	Symbol
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

1.5 Rules and Conventions for Writing SI Units and their Symbols

1. The units named after scientists are not written with a capital initial letter. E.g. newton, henry, ampere and watt.
2. The symbols of the units named after scientists should be written by the initial capital letter. E.g. N for newton, H for henry, A for ampere and W for watt.
3. Small letters are used as symbols for units not derived from a proper noun. E.g. m for metre, kg for kilogram.
4. No full stop or other punctuation marks should be used within or at the end of symbols. E.g. 50 m and not as 50 m.
5. The symbols of the units are not expressed in plural form. E.g. 10 kg not as kgs.
6. When temperature is expressed in kelvin, the degree sign is omitted. E.g. 283 K not as 283° K (If expressed in Celsius scale, degree sign should be included e.g. 100° C not as 100 C, 108° F not as 108 F).
7. Use of solidus is recommended for indicating a division of one unit symbol by another unit symbol. Not more than one solidus is used. E.g. ms^{-1} or m/s. J/K/mol should be JK^{-1} mol^{-1}.
8. The number and units should be separated by a space. E.g. 15 $kgms^{-1}$ not as 15$kgms^{-1}$.
9. Accepted symbols alone should be used. E.g. ampere should not be written as amp and second should not be written as sec.
10. The numerical values of physical quantities should be written in scientific form. E.g. the density of mercury should be written as 1.36×10^4 kg m^{-3} not as 13600 kg m^{-3}.

1.6 Vernier Caliper and Screw Gauge

In our daily life, we use metre scale for measuring lengths. They are calibrated in cm and mm scales. The smallest length which can be measured by metre scale is called least count. Usually the least count of a scale is 1 mm. We can measure the length of objects up to mm accuracy using this scale. But this scale is not sufficient for measuring the size of small spherical objects. So, Vernier caliper and screw gauge are used.

Can you ask for milligram measures of groceries or gram measures of rice from the nearby shop? Can you ask for millimetre measure of cloth? What are the things that you could buy in smaller measures? Why?

1.6.1 Vernier scale

The diameters of spherical objects such as cricket ball and hollow objects such as a pen cap cannot be measured with a meter scale. For that we use an instrument named Vernier caliper which can measure the inner and outer diameters of objects.

Pierre Vernier (1580 – 1637) was a French government official. Vernier was taught mathematics and science by his father who was a lawyer and engineer. He worked much of the time as an engineer, working on the fortifications of various cities. Like many other mathematicians and scientists of that period, Vernier worked on cartography and on surveying. His interest in surveying led him to develop instruments for surveying and this prompted the invention of a precise instrument called Vernier caliper.

1.6.2 Description of Vernier caliper

The Vernier caliper consists of a thin long steel bar graduated in cm and mm. This is the main scale. To the left end of the steel bar an upper and a lower jaw are fixed perpendicular to the bar. These are named as fixed jaws. To the right of the fixed jaws, a slider with an upper and a lower moveable jaw is fixed. The slider can be moved or fixed to any position using a screw. The Vernier scale is marked on the slider and moves along with the movable jaws and the slider. The lower jaws are used to measure the external dimensions and the upper jaws are used to measure the internal dimensions of objects. The thin bar attached to the right side of the Vernier scale is used to measure the depth of hollow objects.

1.6.3 Usage of Vernier caliper

The first step in using the Vernier caliper is to find out its least count, range and zero error.

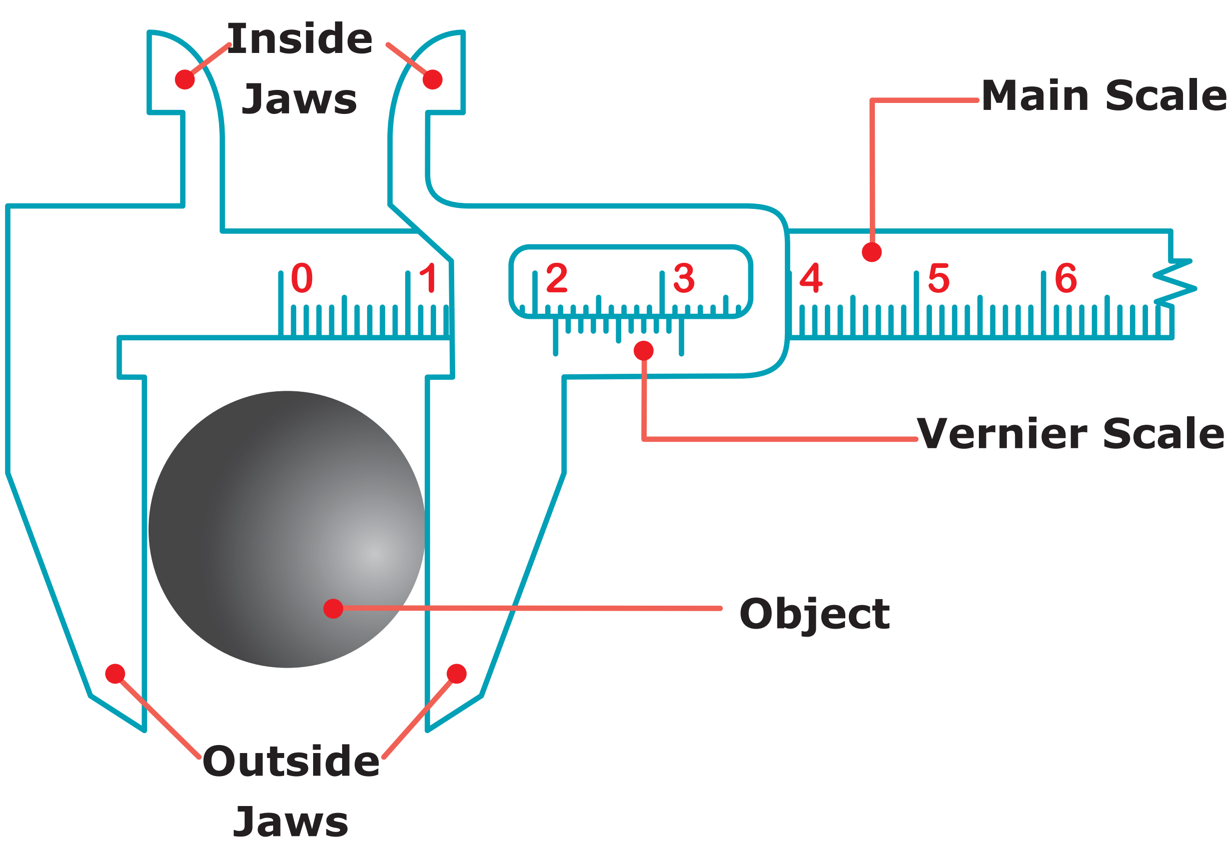


Figure 2 Vernier Caliper

Least count

Least count of the instrument (L.C)

$$= \frac{\text{Value of one smallest main scale division}}{\text{Total number of vernier scale division}}$$

The main scale division can easily be obtained by inspecting the main scale. It will be in centimeter, further divided into millimetre. The value of the smallest main scale division is 1 mm. The Vernier scale division is obtained by counting number of division in it. In the Vernier scale there will be 10 divisions.

$$L.C = \frac{1mm}{10} = 0.1mm = 0.01cm$$

Zero error

Unscrew the slider and move it to the left, such that both the jaws touch each other. Check whether the zero marking of the main scale coincides with that of the Vernier scale. If they are not coinciding with each other, the instrument is said to posses zero error. Zero error may be positive or negative. If the zero mark of the Vernier is shifted to the right, it is called positive error. On the other hand, if the Vernier zero is shifted to the left of the main scale zero marking, then the error is negative.

Positive zero error

Figure 3(a) shows the positive zero error. From the figure you can see that zero of the vernier scale is shifted to the right of zero of the main scale. In this case the reading will be more than the actual reading. Hence, this error should be corrected. In order to correct this error, find out which vernier division is coinciding with any of the main scale divisions. Here, fifth vernier division is coinciding with a main scale division. So, positive zero error = +5 x LC = +5 x 0.01 = 0.05 cm.

(a)

(b)

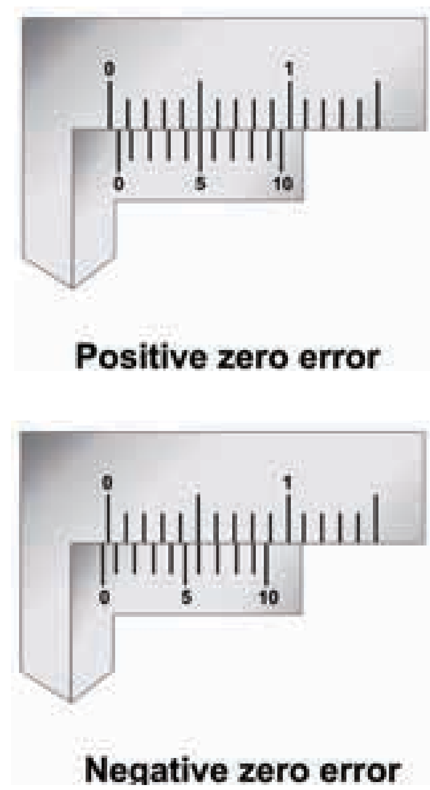


Figure 3 Positive zero error
Negative zero error

Negative zero error

Now look at the Figure 3(b). You can see that zero of the vernier scale is shifted to the left of the zero of the main scale. So, the obtained reading will be less than the actual reading. To correct this error we should first find which vernier division is coinciding with any of the main scale divisions, as we found in the previous case. In this case, you can see that sixth line is coinciding. But, to find the negative error, we can count backward (from 10). So, the fourth line is coinciding. Therefore, negative zero error = -4×LC = -4×0.01 = -0.04 cm.

Example:

Calculate the positive and negative error from the given Figure 4.

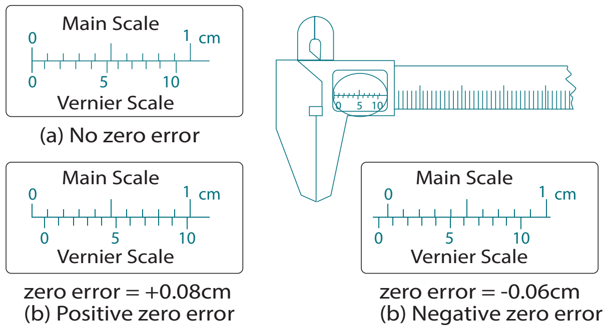


Figure 4 Zero error

Solution:

Case (a): Zero of the vernier scale and zero of the main scale are coinciding with each other. So there is no zero error.

Case (b): The zero of veriner scale is shifted to the right from the zero of the main scale. It is positive error. The 8th division of vernier scale coincides with one of the main scale divisions. So the positive error = (8×0.01cm) = 0.08 cm.

Case (c): The zero of veriner scale is shifted to the left from the zero of main scale. It is negative error. The 4th division of vernier scale (6^{th} from backward) coincides with one of the main scale divisions. So the negative zero error = −(6×0.01cm)= −0.06 cm.

Once you are able to calculate the zero error, you can get the correct reading using the formula:

The correct reading = Main scale reading + (VC × LC) ± (Zero correction)

Zero Correction:

If error is positive the we should subtract that error value. If error is negative, we should add that error value.

For example, let us calculate the correct reading, if the main scale reading is 8 cm, vernier coincidence is 4 and positive zero error is 0.05 cm,

The correct reading = 8 cm + (4 × 0.01cm) – 0.05 cm = 8 + 0.04 – 0.05 = 8 – 0.01 = 7.99 cm

Let us try another one. The main scale reading is 8 cm and vernier coincidence is 4 and negative zero error is 0.02 cm, then the correct reading:

= 8 cm+(4×0.01 cm)+(0.02 cm)

= 8+0.04+0.02 = 8.06 cm.

We can use Vernier caliper to find different dimensions of any familiar object. If the length, width and height of the object can be measured, volume can be calculated. For example, if we could measure the inner diameter of a beaker (using appropriate jaws) as well as its depth (using the depth probe) we can calculate its inner volume.

Example:

Calculate the diameter of the sphere which is shown in the Figure 5. Assume the scale has no zero error.

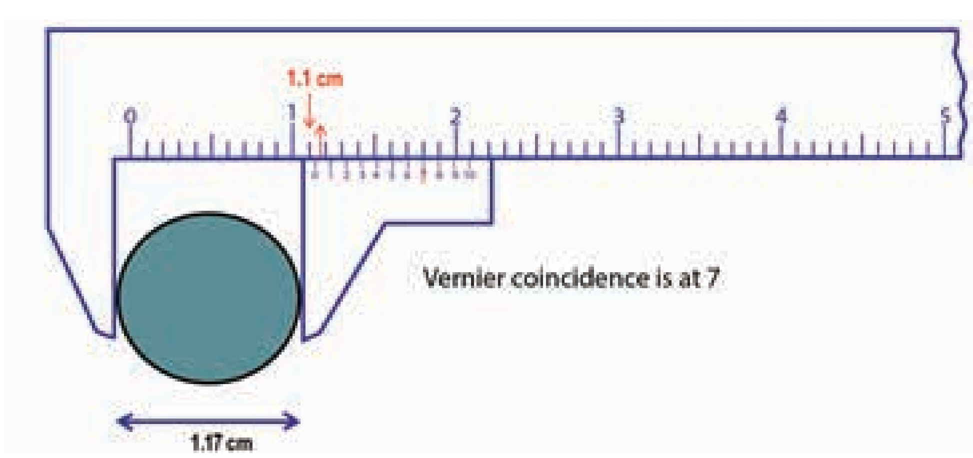


Figure 5 Measuring the diameter of a sphere

The diameter (D) of the sphere = Main scale reading (MSR) + (Vernier scale coincidence (VC) × least count (LC))± ZE. In this case the zero of the vernier scale is right after the main scale reading 1.1. So the main scale reading is 1.1 cm. The vernier scale coincidence is 7. The least count is 0.01 cm. The diameter of the sphere = 1.1 cm + (7 × 0.01cm)-0 = 1.1 + 0.07 = 1.17 cm.

1.6.4 Digital Vernier caliper

Today, we are living in a digital world and the digital version of the vernier callipers are available now. Digital Vernier caliper (Figure 6) has a digital display on the slider, which calculates and displays the measured value. The user need not manually calculate the least count, zero error etc.

Figure 6 Digital Vernier caliper

1.7 Screw Gauge

Measurements made with a Vernier caliper can be made in centimetre only. Hence to measure the length and thickness of very small objects we use a screw gauge. This instrument can measure the dimensions upto 1/100th of a millimetre or 0.01 mm. With the screw gauge it is possible to measure the diameter of a thin wire and the thickness of thin metallic plates.

1.7.1 Description of screw gauge

The screw gauge consists of a U shaped metal frame. A hollow cylinder is attached to one end of the frame. Grooves are cut on the inner surface of the cylinder through which a screw passes (Figure 7).

Activity 1

Find the inner diameter and the depth of a tea cup with Vernier caliper. Record the observation in the table given below.

S.NO		Main Scale Reading MSR × 10^{-2} m	Vernier Scale coincidence	Observed reading OR = MSR + (LC × VC)	Corrected reading = OR ± ZC
Inner diameter	1				
	2				
	3				
	4				
				Average (D)	
depth	1				
r = D/2	2	$V = \pi r^2 h$			
	3				
	4				
				Average (h)	

On the cylinder parallel to the axis of the screw there is a scale which is graduated in millimetre called Pitch Scale (PS). One end of the screw is attached to a sleeve. The head of the sleeve (Thimble) is divided into 100 divisions called the Head scale.

The end of the screw has a plane surface (Spindle). A stud (Anvil) is attached to the other end of the frame, just opposite to the tip of the screw. The screw head is provided with a ratchet arrangement (safety device) to prevent the user from exerting undue pressure.

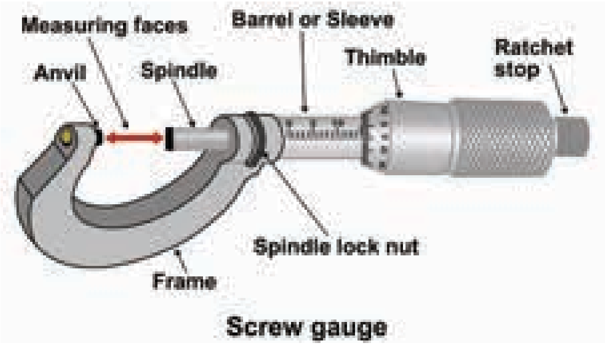


Figure 7 Screw gauge

1.7.2 Using the screw gauge

The screw gauge works on the principal that when a screw is rotated in a nut, the distance moved by the tip of the screw is directly proportional to the number of rotations.

Pitch of the screw

The pitch of the screw is the distance between two successive screw threads. It is also equal to the distance travelled by the tip of the screw for one complete rotation of the head. It is equal to 1 mm in typical screw gauges.

EJL12G

$$\text{Pitch of the screw} = \frac{\text{Distance moved by the Pitch}}{\text{No. of rotations by Head scale}}$$

Least count of a screw gauge

The distance moved by the tip of the screw for a rotation of one division on the head scale is called the least count of the screw gauge.

$$\text{Least count of the instrument (L.C.)} = \frac{\text{Value of one smallest pitch scale reading}}{\text{Total number of Head scale division}}$$

$$LC = \frac{1}{100} = 0.01 \text{ mm}$$

Zero Error of a screw gauge

When the plane surface of the screw and the opposite plane stud on the frame area brought into contact, if the zero of the head scale coincides with the pitch scale axis there is no zero error (Figure 8).

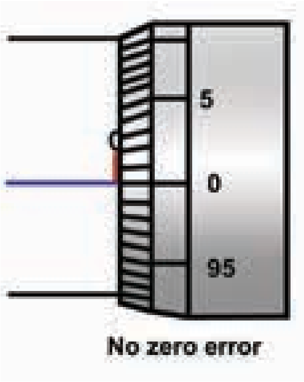


Figure 8 No Zero Error

Positive zero error

When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies below the pitch scale axis, the zero error is positive (Figure 9). For example, the 5th division of the head scale coincides with the pitch scale axis, then the zero error is positive and is given by

Z.E = + (n × LC) where 'n' is the head scale coincidence. In this case, Zero error = + (5 × 0.01) = 0.05mm. So the zero correction is – 0.05 mm.

Figure 9 Positive Zero Error

Negative zero error

When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies above the pitch scale axis, the zero error is negative (Figure 10). For example, the 95^{th} division coincides with the pitch scale axis, then the zero error is negative and is given by

$$ZE = -(100 - n) \times LC$$
$$ZE = -(100 - 95) \times LC$$
$$= -5 \times 0.01$$
$$= -0.05 \text{ mm}$$

The zero correction is + 0.05mm.

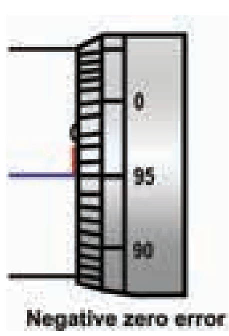


Figure 10 Negative Zero Error

1.7.3 To measure the thickness of a thin coin using a screw gauge

- Determine the pitch, the least count and the zero error of the screw gauge
- Place the coin between the two studs
- Rotate the head until the coin is held firmly but not tightly, with the help of the ratchat
- Note the reading of the pitch scale crossed by the head scale (PSR) and the head scale division that coincides with the pitch scale axis (HSC)
- The width of the coin is given by PSR + CHSR (Corrected HSR). Repeat the experiment for different positions of the coin
- Tabulate the readings
- The average of the last column readings gives the width of the coin

Activity 2

Using screw gauge or Vernier caliper find the outer diameter of your pen cap.

Activity-2

S.No	P.S.R (mm)	H.S.C (division)	CHSC = HSC ± ZC (Division)	CHSR = CHSC × LC (mm)	Total reading = PSR + CHSR (mm)
1					
2					
3					
					mean = mm

Width of the coin = mm

Activity 3

Can you determine the thickness of a single sheet of your science textbook? Justify the answer.

DO YOU KNOW?

The shell of an egg is 12% of its mass. A blue whale can weigh as much as 30 elephants and it is as long as 3 large tour buses.

1.8 Measuring Mass

We commonly use the term 'weight' which is actually the 'mass'. Many things are measured in terms of 'mass' in the commercial world. The SI unit of mass is kilogram. In any case, the units are based on the items purchased. For example, we buy gold in gram or milligram, medicines in milligram, provisions in gram and kilogram and express cargo in tonnes.

Can we use the same instrument for measuring the above listed items? Different measuring devices have to be used for items of smaller and larger masses. In this section we will study about some of the instruments used for measuring mass.

Common (beam) balance

A beam balance compares the sample mass with a standard reference mass. (Standard reference masses are 5g, 10g, 20g, 50g, 100g, 200g, 500g, 1kg, 2kg, 5kg). This balance can measure mass accurately up to 5g (Figure 11).

Figure 11 Common beam balance

Two pan balance

This type of balance is commonly used in provision and grocery shops (Figure 12). This balance compares the sample mass with the standard reference mass. The pans rest on top of the beam and can be conveniently placed on a table top. This balance can measure mass accurately upto 5 g.

Figure 12 Two pan balance

Physical balance

This balance is used in labs and is similar to the beam balance but it is a lot more sensitive and can measure mass of an object correct to a milligram (Figure 13).

The standard reference masses used in this physical balance are 10 mg, 20 mg, 50 mg, 100 mg, 200 mg, 500 mg, 1 g, 2g, 5 g, 10 g, 20 g, 50 g, 100g, and 200 g.

Figure 13 Physical balance

Activity 4

Visit a provision shop, grocery shop, jewellery shop, timber mart and a heavy vehicle weighing bridge with the guidance of your teacher. Observe the different devices used for measuring the accurate mass and the operating range of the device used in each case.

Digital balance

Nowadays for accurate measurements digital balances are used, which measures mass accurately even up to a few milligrams, the least value being 10 mg (Figure 14). This electrical device is easy to handle and commonly used in jewellery shops and labs.

Figure 14 Digital balance

Activity 5

With the resources available at home such as paper plates, tea cups, thread and sticks make a model of an ordinary balance. Using standard masses find the mass of some objects.

Spring balance

This balance helps us to find the weight of an object. It consists of a spring fixed at one end and a hook attached to a rod at the other end. It works by 'Hooke's law' which explains that the addition of weight produces a proportional increase in the length of the spring (Figure 15). A pointer is attached to the rod which slides over a graduated scale on the right. The spring extends according to the weight attached to the hook and the pointer reads the weight of the object on the scale.

Figure 15 Spring balance

Solve – The mass of 40 apples in a box is 10 kg. (i) Find the mass of a dozen of them (ii) Express the mass of one apple in gram.

1.8.1 Difference between mass and weight

Mass (m) is the quantity of matter contained in a body. Weight (w) is the normal force (N) exerted by the surface on the body to balance against gravitational pull on the object. In the case of spring scale the tension in the spring balances the gravitational pull on the object. When the man is standing on the surface of the earth or floor, the surface exerts a normal force on the body which is equivalent to gravitational force. The gravitational force acting on the object is given by 'mg'. Here m is mass of the object and 'g' is acceleration due to gravity.

If a man has a mass 50 kg on the earth, then what is his weight?

Weight (w) = mg
Mass of a man = 50 kg
His weight = 50×9.8
w = 490 newton

Mass	Weight
1. Fundamental quantity	Derived quantity
2. Has magnitude alone – scalar quantity	Has magnitude and direction – vector quantity
3. It is the amount of matter contained in a body	It is the normal force exerted by the surface on the object against gravitational pull
4. Remains the same	Varies from place to place

Mass	Weight
5. It is measured using physical balance	It is measured using spring balance
6. Its unit is kilogram	Its unit is newton

The pull of gravity on the Moon is 1/6 times weaker than that on the Earth. This causes the weight of the object on the Moon to be less than that on the Earth.

Acceleration due to gravity on the Moon = $1.63 m/s^2$

If the mass of a man is 70 kg then his weight on the Earth is 686 N and on the Moon is 114 N. But his mass is still 70 kg on the Moon.

1.9 Accuracy in Measurements

When measuring physical quantities, accuracy is important. Accuracy represents how close a measurement comes to a true value. Accuracy in measurement is center in engineering, physics and all branches of science. It is also important in our daily life. You might have seen in jewellery shops how accurately they measure gold. What will happen if little more salt is added to food while cooking? So, it is important to be accurate when taking measurements.

Faulty instruments and human error can lead to inaccurate values. In order to get accurate values of measurement, it is always important to check the correctness of the measuring instruments. Also, repeating the measurement and getting the average value can correct the errors and give us accurate value of the measured quantity.

Points to remember

- Length, mass, time, temperature, electric current, intensity and mole are the fundamental units in SI system
- To find the length or thickness of smaller dimensions Vernier caliper or screw gauge are used
- Austronomical unit is the mean distance of the sun from center of the earth $1AU=1.496 \times 10^{11}m$
- Light year is the distance travelled by light in one year in vacuum. 1 Light year = $9.46 \times 10^{15}m$
- Parsec is the unit distance used to measure astronomical objects outside the solar system
- 1 Angstrom (Å) = 10^{-10} m
- SI Unit of volume is cubic metre or m^3. Generally volume is represented in litre (l). $1ml=1cm^3$
- C/100 = (F -32)/180 = (K -273)/100
- Least count of screw gauge is 0.01 mm. Lease count of Vernier caliper is 0.01 cm
- Common balance can measure mass accurately upto 5 g
- Accuracy of physical balance is 10 mg

A-Z GLOSSARY

1. **Metre [m]** The metre is the basic unit of length. It is the distance light travels, in a vacuum, in 1/299792458th of a second.
2. **Kilogram [kg]** The kilogram is the basic unit of mass. It is the mass of an international prototype in the form of a platinum-iridium cylinder kept at Sevres in France. It is now the only basic unit still defined in terms of a material object, and also the only one with a prefix [kilo] already in place.

3. **Second [s]** The second is the basic unit of time. It is the length of time taken for 9192631770 periods of vibration of the Caesium-133 atom to occur.
4. **Ampere [A]** The ampere is the basic unit of electric current. It is that current which produces a specified force between two parallel wires which are 1 metre apart in a vacuum.
5. **Kelvin [K]** The kelvin is the basic unit of temperature. It is 1/273.16th of the thermodynamic temperature of the triple point of water.
6. **Mole [mol]** The mole is the basic unit of a substance. It is the amount of the substance that contains as many elementary units as there are atoms in 0.012 kg of carbon-12.
7. **Candela [cd]** The candela is the basic unit of luminous intensity. It is the intensity of a source of light of a specified frequency, which gives a specified amount of power in a given direction.
8. **Farad [F]** The farad is the SI unit of the capacitance of an electrical system, that is, its capacity to store electricity. It is rather a large unit as defined and is more often used as a microfarad.
9. **Joule [J]** The joule is the SI unit of work or energy. One joule is the amount of work done when an applied force of 1 newton moves through a distance of 1 metre in the direction of the force.
10. **Newton [N]** The newton is the SI unit of force. One newton is the force required to give a mass of 1 kilogram an acceleration of 1 metre per second^2.
11. **Ohm [Ω]** The ohm is the SI unit of resistance of an electrical conductor. Its symbol is the capital Greek letter 'omega'.
12. **Pascal [Pa]** The pascal is the SI unit of pressure. One pascal is the pressure generated by a force of 1 newton acting on an area of 1 square metre. It is rather a small unit as defined and is more often used as a kilopascal [kPa].
13. **Volt [V]** The volt is the SI unit of electric potential. One volt is the difference of potential between two points of an electical conductor when a current of 1 ampere flowing between those points dissipates a power of 1 watt.
14. **Watt [W]** The watt is used to measure power or the rate of doing work. One watt is a power of 1 joule per second. Electrical power V × I = W.

ICT CORNER

MEASUREMENT - VERNIER CALIPER

Vernier is a visual aid that helps the user to measure the internal and external diameter of the object.

This activity helps the students to understand the usage better

Step 1. Type the following URL in the browser or scan the QR code from your mobile. Youcan see"Vernier caliper" on the screen.

Step 2. The yellow colour scale is movable. Now you can drag and keep the blue colour cylinder in between. Now you can measure the dimension of the cylinder. Use the + symbol to drag cylinder and scale.

Step 3. Now go to the place where you can enter your answer. An audio gives you the feedback and you can see the answer on the screen also

B121_9_SCI_EM

https://play.google.com/store/apps/details?id=com.ionicframework.vernierapp777926

EXERCISE

I. Multiple Choice Questions

1. Choose the correct one
   a. mm< cm < m < km
   b. mm > cm > m > km
   c. km < m < cm < mm
   d. mm > m> cm> km
2. Rulers, measuring tapes and metre scales are used to measure
   a. Mass
   b. Weight
   c. Time
   d. Length
3. 1 metric ton is equal to
   a. 100 quintals   b. 10 quintals
   c. 1/10 quintals   d. 1/100 quintals
4. Distance between Chennai and Kanyakumari can be found in
   a. Kilometres   b. Metres
   c. Centimetres   d. Millimetres
5. Which among the following is not a device to measure mass?
   a. Spring balance
   b. Beam balance
   c. Physical balance
   d. Digital balance

II. Fill in the blanks

1. Metre is the unit of _________
2. 1 kg of rice is weighed by ______
3. The thickness of a cricket ball is measured by _______
4. The radius of a thin wire is measured by _________
5. A physical balance measures small differences in mass up to ______

EJUH44

III. True or False

1. The SI unit of electric current is kilogram
2. Kilometre is one of the SI units of measurement
3. In everyday life, we use the term weight instead of mass.
4. A physical balance is more sensitive than a beam balance as it can accurately measure even a very small mass, even milligram
5. One Celsius degree is an interval of 1K and zero degree Celsius is 273.15 K.

IV. Match the following

1.

Column I	Column II
Length	Kelvin
Mass	metre
Time	kilogram
Temperature	second

2.

Column I	Column II
Screw gauge	Vegetables
Vernier caliper	Coins
Beam balance	Gold ornaments
Digital balance	Cricket ball

3.

Column I	Column II
Temperature	Beam balance
Mass	Ruler
Length	Digital clock
Time	Thermometre

V. Assertion and reason type

1. Assertion (A): The SI systems of units is the improved system of units for measurement.

   Reason (R): The SI unit of mass is kilogram

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

2. Assertion (A): The skill of estimation is important for all of us in our daily life.

   Reason (R): The skill of estimation reduces our consumption of time

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

3. Assertion(A): The scientifically correct expression is " The mass of the bag is 10 kg"

   Reason (R): In everyday life, we use the term weight instead of mass

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

4. Assertion (A): 0 °C = 273.16 K. For our convenience we take it as 273 K after rounding off the decimal

   Reason (R): To convert a temperature on the Celsius scale you have to add 273 to the given temperature

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

5. Assertion (A): The distance between two celestial bodies is measured in the unit of light year

   Reason (R): The distance travelled by the light in one year is one light year

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

VI. Comprehensive type

Read the passage and answer the questions given below.

Mass is the amount of matter contained in an object. Measurement of mass helps us to distinguish between a lighter and a heavier body. Beam balance, spring balance and electronic balance are used to measure mass of different objects. The SI unit of mass is the kilogram (kg). But different units are used to measure the mass of different objects. E.g. weight (mass) of a tablet is measured in milligrams (mg), weight of a student is measured in kilogram (kg) and weight of a truck with goods is measured in metric tons. 1 metric ton is equal to 10 quintals and 1 quintal is equal to 100 kg. 1 gram is equal to 1000 mg.

1. The value of 1 metric ton is equal to

   a. 1000 kg b. 10 quintals
   c. 10,00,000 g d. 100 kg

2. How will you measure the weight of a tablet?

   a. kg b. g
   c. mg d. None of these

VII. Very short answer type

1. Define measurement.
2. Define standard unit.
3. What is the full form of SI system?
4. Define least count of any device.

5. What do you know about pitch of screw gauge?
6. Can you find the diameter of a thin wire of length 2 m using the ruler from your instrument box?

VIII. Short answer type

1. Write the rules that are followed in writing the symbols of units in SI system.
2. Write the need of a standard unit
3. Differentiate mass and weight
4. What is the measuring unit of the thickness of a plastic carry bag?
5. How will you measure the least count of vernier caliper?

IX. Numerical Problem

1. Inian and Ezhilan argue about the light year. Inian tells that it is 9.46×10^{15} m and Ezhilan argues that it is 9.46×10^{12} km. Who is right? Justify your answer.
2. The main scale reading while measuring the thickness of a rubber ball using Vernier caliper is 7 cm and the Vernier scale coincidence is 6. Find the radius of the ball.
3. Find the thickness of a five rupee coin with the screw gauge, if the pitch scale reading is 1 mm and its head scale coincidence is 68.
4. Find the mass of an object weighing 98 N.

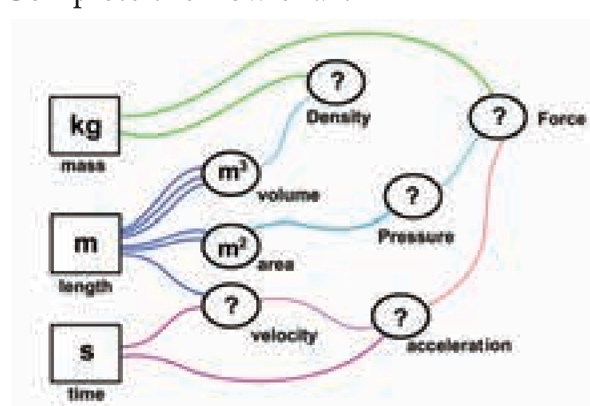
X. Long answer type

1. Explain a method to find the thickness of a hollow tea cup.
2. How will you find the thickness of a one rupee coin?
3. Find out any 'ten words' related to measurement from the grid.

A	C	C	U	R	A	T	E	V	B
N	U	O	P	I	E	R	R	E	E
A	B	N	I	S	N	I	R	R	A
L	I	S	T	C	D	A	O	N	M
O	T	T	C	R	F	L	R	I	B
G	Z	A	H	E	H	S	M	E	A
U	Y	N	E	W	T	O	N	R	L
E	G	T	R	A	I	L	E	R	L
L	E	A	S	T	C	O	U	N	T
K	E	L	V	I	N	O	T	E	C
X	B	E	A	M	B	A	N	C	E

XII. Activity - 6

Complete the flow chart



REFERENCE BOOKS

1. Units and measurements – John Richards, S. Chand publishing, Ram nagar, New Delhi.
2. Units of Measurement - Past, Present and Future. International System of Units - Gupta, S. V. eBook ISBN 978-3-642-00738-5 DOI 10.1007/978-3-642-00738-5
3. Complete physics(IGCSE) - Oxford University press, New York
4. Practical physics – Jerry. D. Wilson – Saunders college publishing, USA

INTERNET RESOURCES

http://www.npl.co.uk/reference/measurement-units/

http://www.splung.com/content/sid/1/page/units

http://www.edinformatics.com/math_science/units.htm

https://www.unc.edu/~rowlett/units/dictA.html

https://study.com/academy/lesson/standard-units-of-measure.html