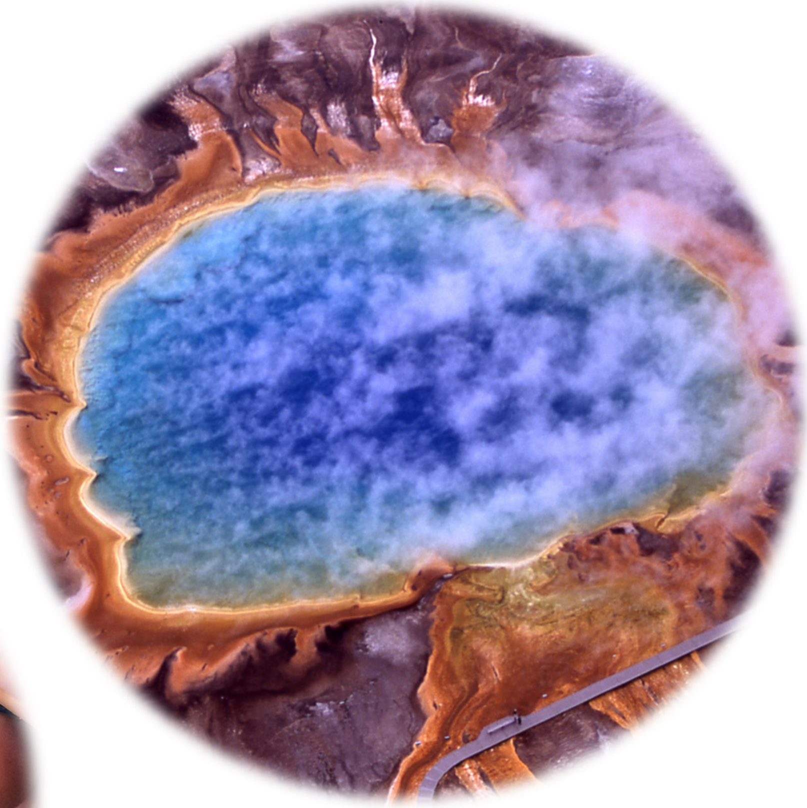
educàlia editorial



Raquel Manso Escuadra

Alicia Sampedro Montañés

Physics & Chemistry

Student's book

3

ESO

LOMLOE Edition

Edición, 2024
Autora: Raquel Manso Escuadra y Alicia Sampedro Montañés
Diseño de la portada: Susana Arroyo Hernández
Maquetación: Ángela Fernandéz Carretero
Edita: Educàlia Editorial
Imágenes: Freepik y Canva
Imprime: Grupo Digital 82, S. L.
ISBN: 978-84-941593-5-0
Depósito Legal: V-2098-2013
Printed in Spain/Impreso en España.

Educàlia Editorial

Avda. de las Jacarandas 2 loft 327 46100 Burjassot-València

Tel. 960 624 309 - 963 768 542 - 610 900 111

Email: educaliaeditorial@e-ducalia.com

www.e-ducalia.com

UNIT 1. INTRODUCTION TO THE SCIENTIFIC METHOD.

1. The scientific method. Its steps.
2. Reading comprehension: Galileo and falling bodies.
3. Measurements and magnitudes. International units system. Multiples and submultiples. Scientific notation.
4. Sensitivity and precision. Significant digits.
5. Measurements errors.
6. Data analysis in charts and graphs.
7. Learning situation: Measurement errors.
8. Working in the lab. Laboratory material.
9. Development of a research project.
10. Learning situation: Measuring the density of a substance.
11. Vocabulary review.
12. Scientific method. Vocabulary.
13. Final activities.

UNIT 2. THE ATOM AND THE PERIODIC TABLE

1. Listening comprehension: History of atomic models.
2. Atomic models from Democritus to Rutherford.
3. Atomic structure. Subatomic particles.
4. Atomic and mass number.
5. Chemical elements and isotopes.
6. Electron configuration. Ion formation.
7. Periodic table of the elements. Periodic properties.
8. Reading comprehension: Marie Curie, Idda Noddack and Lise Meitner: Three female scientists that studied nuclear processes.
9. Learning situation: Differences between metals and non-metals.
10. Vocabulary review.
11. Final activities.

UNIT 3. CHEMICAL BONDS

1. Reading comprehension: Bonds between atoms
2. Chemical bonds between atoms: Molecules and crystals..
3. Properties of substances and particles behavior.
4. Ionic bonds. Ionic substances.
5. Covalent bonds. Atomic and molecular substances.
6. Metallic bonds. Metallic substances.
7. Atomic and molecular mass.
8. The mole. Molar mass.
9. Learning situation: Chemical bond properties.
10. Vocabulary review.
11. Final activities.

UNIT 4. CHEMICAL REACTIONS

1. Physical mixture and chemical reaction. Mass conservation.
2. Balance on chemical equations.
3. Molar, mass and volume calculations in chemical equations.
4. Learning situation: Physical or chemical process.
5. Rate on chemical reactions. Collision theory.
6. Learning situation: Observation of chemical reactions.
7. Reading comprehension: Acid rain, greenhouse effects and ozone layer destruction.
7. Vocabulary review.
8. Final activities.

UNIT 5. INTRODUCTION TO THE STUDY OF MOTION

1. Kinematics. General study of a body in motion.
2. Velocity of light.
3. Uniform rectilinear motion.
4. Acceleration.
5. Introducction to uniformly acelerated rectilinear motion.
6. Learning situation. Studing the motion of toys.
7. Vocabulary review.
8. Final activities.

UNIT 6. INTRODUCTION TO THE STUDY OF FORCES. GRAVITATIONAL FORCE

1. Interactions between bodies: Forces. Types of forces.
2. Vectorial representation of forces. Free-body diagrams.

UNIT 7. ELECTRICAL FORCE

UNIT 8. ELECTROMAGNETISM

UNIT 9. ENERGY

UNIT 10. ELECTRICAL CURRENT

APPENDIX: INORGANIC FORMULATION

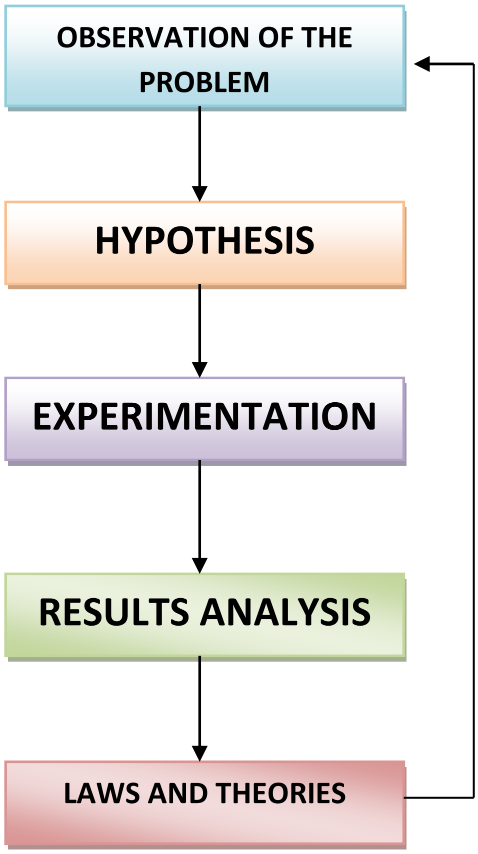
UNIT 1

INTRODUCTION TO THE SCIENTIFIC METHOD.

1. THE SCIENTIFIC METHOD.ITS STEPS.

The scientific method is a set of techniques used by the scientist to construct knowledge.

The steps of the scientific method are the following:

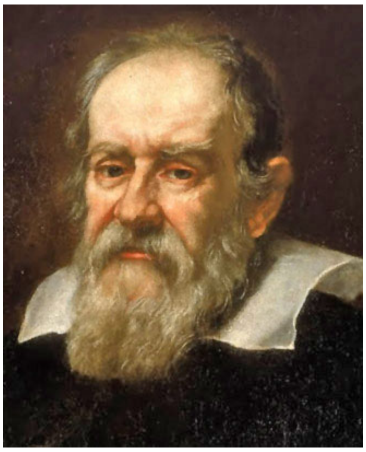


It is important to understand that laws and theories are not valid forever. Often, throughout the history of science, some theories were considered to be true for centuries until something observed made them to be replaced with other new theories.

We will see an example on the next point.

2. READING COMPREHENSION: GALILEO AND FALLING BODIES.

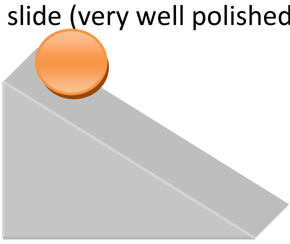
Since the ancient Greeks there was a thought among the scientist (mainly because of Aristotle): heavy bodies fall faster than light bodies.



Probably you think so too (or you have thought it) but what is really surprising is that for nearly 20 centuries nobody considered the possibility to prove that fact, they just believed it without asking.

But in the XVI century a greatest scientist, Galileo Galilei, was not very convinced that mass and velocity where proportional, so he designed an experiment to prove it.

You have to think that in those times watches weren't as accurate as they are nowadays (in fact, he used a water watch), so Galileo couldn't make the test with free falling bodies, he made build a 7 meter slide (very well polished to avoid friction) and let different balls fall.



What he discovered, after several measurements of time and distance, was that, when there is no friction, mass and velocity are independent and two bodies with different shapes and masses will fall within the same time.

Galileo, with this experiment, is considered the father of the scientific method.

Answer the next questions about the text:

1. Identify the different steps of the scientific method in Galileo's history.
2. What does it mean that mass and velocity are proportional?
3. Describe how you think a water watch works.
4. If mass and velocity are actually independent, why a piece of paper fall slower than a stone?

3. MEASUREMENTS AND MAGNITUDES.INTERNATIONAL UNITS SYSTEM.MULTIPLES AND SUBMULTIPLES.SCIENTIFIC NOTATION.

A Physical Magnitude is any property that can be measured. For example, temperature and volume are magnitudes but beautiful or happiness are not.

But, what is to measure a magnitude? **To measure a magnitude** is to compare it with another that we have chosen as unit to determine how many times the magnitude contains the unit.

For measuring we need a unit. We cannot say "that glass has a volume of 300", we need to indicate the unit in which we measure.

3.1 International System of Units.

To avoid misunderstandings when we talk about measurements, it is necessary to use the same unit system for everybody.

That is what the **International Units System** represents for most of the countries in our world.

According to it, the main units are the following:

UNIT	ABBREVATION	Fundamental Magnitude
METRE	m	Length
KILOGRAM	kg	Mass
SECOND	s	Time
AMPERE	A	Current
KELVIN	K	Temperature
MOLE	Mol	Amount of substance
CANDELA	cd	Luminous intensity

Derived magnitudes are those that depend on fundamental magnitudes and are obtained from them. The table below shows some derived magnitudes that you will work with this year:

DERIVED MAGNITUDE	DEPENDS ON	ITS UNIT
SURFACE	LENGTH	m^2
VOLUME	LENGTH	m^3
VELOCITY	LENGTH and TIME	m/s
ACCELERATION	LENGTH and TIME	m/s^2
DENSITY	MASS and LENGTH	kg/m^3
FORCE	MASS, LENGTH and TIME	$N=kg \cdot m/s^2$

Notice that the International Unit System for measuring surfaces will be the square meter (m^2) and for volumes will be the cubic meter (m^3) although the most used unit for volumes is the litre (ℓ) which is the same as 1 dm^3.

In some countries, like the English-speaking ones, other units are used:

UNIT	ABBREVATION	Magnitude
INCH	In	Length
FOOT	Ft	Length
YARD	Yd	Length
MILE	Mi	Length
QUART	Qt	Volume
GALLON	Gal	Volume
PINT	Pt	Volume
OUNCE	Oz	Mass
POUND	Lb	Mass
FAHRENHEIT	ºF	Temperature

The equivalence between our system and the English one is:

1 inch = 0,0254 m.
1 foot = 0,3048 m.
1 yard = 0,9144 m.
1 mile = 1609,344 m.
1 quart = 1136,5225 mℓ.
1 gallon = 4546,09 mℓ.
1 pint = 568,2612 mℓ.
1 ounce = 28,349 g.
1 pound = 453,592 g.

3.2 Multiples and submultiples

Sometimes, for measuring very large or very small quantities it is useful to use different units than the ones of the International System. For that reason, we use the multiples and submultiples than can be seen in the next table:

MULTIPLES AND SUBMULTIPLES		
FACTOR	PREFIX	SYMBOL
10^{1}	deca	da
10^{2}	hecto	h
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	mili	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

LENGTH, SURFACE AND VOLUME. CHARTS OF UNITS

LENGTH UNITS	
	Equivalence with the International System Unit
Tm	1 Tm = 10^{12} m
Gm	1 Gm = 10^{9} m
Mm	1 Mm = 10^{6} m
km	1 km = 10^{3} m
hm	1 hm = 10^{2} m
dam	1 dam = 10 m
m	
dm	10 dm = 1 m
cm	10^{2} cm = 1 m
mm	10^{3} mm = 1 m
µm	10^{6} µm = 1 m
nm	10^{9} nm = 1 m
pm	10^{12} pm = 1 m
fm	10^{15}fm = 1 m
am	10^{18} am = 1 m
SURFACE UNITS	
	Equivalence with the International System Unit
Tm^2	1 Tm^2 = 10^{24} m^2
Gm^2	1 Gm^2 = 10^{18} m^2
Mm^2	1 Mm^2 = 10^{12} m^2
km^2	1 km^2 = 10^{6} m^2
hm^2	1 hm^2 = 10^{4} m^2
dam^2	1 dam^2 = 10^{2} m^2
m^2	
dm^2	10^{2} dm^2 = 1 m^2
cm^2	10^{4} cm^2 = 1 m^2
mm^2	10^{6} mm^2 = 1 m^2
$µm^2$	10^{12} $µm^2$ = 1 m^2
nm^2	10^{18} nm^2 = 1 m^2
pm^2	10^{24} pm^2 = 1 m^2
fm^2	10^{30} fm^2 = 1 m^2
am^2	10^{36} am^2 = 1 m^2

VOLUME UNITS		
	Equivalence with the International System Unit	Equivalence with Capacity units
Tm^3	1 Tm^3 = 10^{36} m^3	
Gm^3	1 Gm^3 = 10^{27} m^3	
Mm^3	1 Mm^3 = 10^{18} m^3	
km^3	1 km^3 = 10^9 m^3	
hm^3	1 hm^3 = 10^6 m^3	
dam^3	1 dam^3 = 10^3 m^3	
m^3		1 kℓ = 1 m^3
dm^3	10^3 dm^3 = 1 m^3	1ℓ = 1 dm^3
cm^3	10^6 cm^3 = 1 m^3	1 mℓ = 1 cm^3
mm^3	10^9 mm^3 = 1 m^3	
μm^3	10^{18} μm^3 = 1 m^3	
nm^3	10^{27} nm^3 = 1 m^3	
pm^3	10^{36} pm^3 = 1 m^3	
fm^3	10^{45} fm^3 = 1 m^3	
am^3	10^{54} am^3 = 1 m^3	

CONVERSION FACTORS.

To change from one unit to another we use conversion factors. A conversion factor is a fraction that expresses the equivalence between two units. For example:

From the equivalence 1 m =10^2 cm

We can obtain two conversion factors:

$$\frac{1\,m}{10^2cm} \quad or \quad \frac{10^2cm}{1\,m}$$

But, how conversion factors are used? Look at the following examples:

1. To convert from one unit to a multiple or submultiples we use powers of ten:

How many meters are 2 cm?

$$2cm \cdot \frac{1m}{10^2cm} = \frac{2cm \cdot 1m}{100cm} = \frac{2}{100}m = 0{,}02m$$

2. If there is no power of ten we simply use the equivalence:

How many hours are 60 s?

$$60s \cdot \frac{1h}{3600s} = \frac{60s \cdot 1h}{3600s} = \frac{60}{3600}h = 0{,}016h$$

3. If we have to make more than one change we use more than one fraction

How many km/h are 20 m/s?

$$\frac{20\,m}{1\,s} \cdot \frac{1km}{1000m} \cdot \frac{3600s}{1h} = \frac{20m \cdot 1km \cdot 3600s}{1s \cdot 1000m \cdot 1h} = 72\, {}^{km}/_{h}$$

3.3 Scientific notation

In Physics and Chemistry we may find very long numbers, as the velocity of light which is 299792458 meters per second and very small numbers as the proton's mass, which is 0,000000000000000000000000000167 kg.

To write that type of numbers we use scientific notation, which uses powers of ten to rewrite the numbers in a shorter way.

HOW TO WRITE NUMBERS IN SCIENTIFIC NOTATION:

You should leave just one number before the coma. To know how many decimals you should write, read point 4.

- *If the number is bigger than one:*
  - *Multiply for 10 powered to the number of places you move to the coma.*

  Example: 299292458 = $2,99 \cdot 10^{8}$
- *If the number is smaller than one:*
  - *Multiply for 10 powered to minus the number of places you move the coma (remember that multiplying for a negative power is the same as dividing for it):*

$$2 \cdot 10^{-3} = \frac{2}{10^3}$$

  Example: 0,000000000000000000000000000167 = $1,67 \cdot 10^{-27}$

EXERCISES

1. Rewrite these measurements using scientific notation: (leave two decimals behind the coma)

a. 0,00075 m	g. 96840 g
b. 1257000 µm	h. 450000000 fm
c. 548900000 s	i. 0,00025776 Mg
d. 0,000076 km	j. 85651798 ns
e. 726582000 ℓ	k. 0,00000624 Gg
f. 27229 mm	l. 7884329 hℓ

2. Rewrite these numbers into decimal notation:

   a. $2·10^{-5}$
   b. $5,35·10^{-6}$
   c. $6,7·10^{3}$
   d. $4,56·10^{9}$
   e. $2,4·10^{-9}$

3. Solve the next operations:

   a. $(10^3)^5$
   b. $(10^2)^3$
   c. $(10^2·10^5)^3$
   d. $10^3·10^{-3}$
   e. $10^3 + 10^2$
   f. $(10^5 + 10^6)/100$
   g. $(10^5·10^6)/100$
   h. $3·(10^2)^3+5·(10^3)^2$

4. Convert the following measurements to meters using conversion factors and express in scientific notation:

   a. 38 mm
   b. 230 cm
   c. 40 pm
   d. 27 km
   e. 1200 nm
   f. 430 µm
   g. 3 Gm
   h. 58 hm

5. Convert the following measurements to square meters using conversion factors and express in scientific notation:

   a. 27 cm^2
   b. 76000 mm^2
   c. 52 km^2
   d. 3500 nm^2

6. Convert the following measurements to cubic meters using conversion factors and express in scientific notation:

   a. 47 dm^3
   b. 12 dam^3
   c. 480 ℓ
   d. 930 mℓ
   e. 950 mm^3
   f. 47000 dℓ

7. Make the following time conversions using conversion factors and express in scientific notation:

   a. 6530 s to hours
   b. 7 h to min
   c. 450 s to min
   d. 8800 µs to hours

8. Make the following mass conversions using conversion factors and express in scientific notation:

   a. 54000 µg to kg
   b. 600 Tg to kg
   c. 580 dag to kg
   d. 32 dg to mg

9. Make the following conversions using conversion factors:

   a. 5 cm to inches
   b. 4 km to miles
   c. 25 feet to meters
   d. 15 yards to km
   e. 2 pints to litres
   f. 30 pounds to kg

4. SENSITIVITY AND PRECISION. SIGNIFICANT DIGITS.

When we measure, we use a measuring instrument, which will have certain sensitivity and precision:

- **Sensitivity:** The smallest change unit that an instrument can detect.
- **Precision:** Degree to which repeated measurements under the same conditions show the same results.

Therefore, when we talk about measurements, we have to considerate the sensitivity of the measuring instruments. The results of our calculations should never have more digits than the sensitivity of the instrument used.

4.1 Significant digits

The number of significant digits used in an answer to a calculation depends on the number of significant digits in the given data.

To know how many significant digits a measurement has, we have to follow the following rules:

1. Non-zero digits are always significant.
2. Zeroes placed between other digits are always significant; 5007 kg has four significant digits and 200,03 m has 5 significant digits.
3. Zeroes placed after other digits but behind a decimal point are significant; 6,50 has three significant digits.
4. Zeroes placed before other digits are not significant; 0,032has two significant digits.

Example: How many significant figures are present in the following numbers?

Number	Significant Figures	Rule(s)
35,712	5	1
2469	4	1
400,05	5	1,2
0,003 = $3\ 10^{-3}$	1	1,4
6,500	4	1,3
705,0200	7	1,2,3,4
3000000 = $3\ 10^{6}$	1	1
1,000	4	1,3

When we are operating, we should pay attention to the following rules:

- In additions and subtractions, the result of the operation cannot have more decimal places than the smallest number of decimal places in the numbers being added or subtracted.
- In multiplication and division, the answer cannot contain more significant digits than the numbers being multiplied or divided.

EXERCISES

10. How many significant digits are there in the next numbers?

a. 3400
b. 0,000078
c. 0,340
d. 123,00
e. 24
f. 12302,02
g. 23,002
h. 0,0023

11. Round off the next numbers so they have 4 significant digits:

Example: 1,8359 = 1,836

a. 23,5
b. 0,023456
c. 23,456
d. 12,03

12. Solve the next operations leaving the result with the appropriate number of digits:

a. 45·125
b. 123,4 + 13,4567
c. 12,34·34,5 + 123
d. 1,56 + 12,3·4,5

5. MEASUREMENTS ERRORS.

When we measure, as we are humans, we make errors.

We can classify errors into two groups:

- Random errors are always present in every measurement. They are unpredictable and unavoidable.
- Systematic errors are caused by a bad measure or for a bad calibration of the measuring instrument. So, this kind of errors can be avoidable.

As we cannot avoid random errors, we have to keep them in mind when we measure. The best way to minimize them is to make as many measures as possible and, in this way, we can consider the average of our result as the best value:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n}$$

Being n the number of measures taken and x_i the value of each measure.

But then, what is the error of our measurement? We have two ways of measuring errors:

- **Absolute error**: $\varepsilon_{a_i} = /\bar{x} - x_i/$ gives as the error for each measure compared with the average (always positive).

- The **average of the absolute error** is the one that we usually take as the error of the measure, although if this average is lower than the sensitivity of the measurement instrument, we should take this sensitivity as the final error.

  For example, the correct value of a mass measurement expressed as **1,234 ± 0,004 g**, means that the measurement value is between 1,230g and 1,238g.

- **Relative error:** is calculated by division of the absolute error into the average measurement. To express percentage, it is multiplied by a hundred. For example, if the correct value of a measurement is expressed as **2,345 ± 0,003 g** it is known that:

  a. The average mass is 2,345 g
  b. The absolute error is 0,003 g

  The relative error is calculated:

$$\boldsymbol{\varepsilon_r = \frac{\varepsilon_r}{\bar{x}} \cdot 100}$$

In the previous example

$$\varepsilon_r = \frac{0{,}003g}{2{,}345g} \cdot 100 = 0{,}128\%$$

A relative error under 1% means a good precision in the measuring method.

A relative error over 10% implies a no precise measuring method.

EXAMPLE:

In the lab, we have been measuring the temperature of boiling water. With a digital thermometer we have measured the next temperatures:

100,1 ºC	98,7 ºC	99,2 ºC	101,2 ºC	100,0 ºC

a) What is the sensitivity of the thermometer?

0,1 º C

b) What is the average of the measure?

$$\bar{x} = \frac{101{,}1^0C + 98{,}7^0C + 99{,}2^0C + 101{,}2^0C + 100{,}0^0C}{5} = 99{,}8^0C$$

c) What is the absolute error of each measure?

$$\varepsilon_{a_1} = 99{,}8^0C - 100{,}1^0C = 0{,}3^0C$$

$$\varepsilon_{a_2} = 99{,}8^0C - 98{,}7^0C = 1{,}1^0C$$

$$\varepsilon_{a_3} = 99{,}8^0C - 99{,}2^0C = 0{,}6^0C$$

$$\varepsilon_{a_4} = 99{,}8^0C - 101{,}2^0C = 1{,}4^0C$$

$$\varepsilon_{a_5} = 99{,}8^0C - 100{,}0^0C = 0{,}2^0C$$

d) What is the average of the absolute error?

$$\varepsilon_a = \frac{0{,}3^0C + 1{,}1^0C + 0{,}6^0C + 1{,}4^0C + 0{,}2^0C}{5} = 0{,}7\ ^0C$$

e) What is the relative error of this measure?

$$\varepsilon_r = \frac{0{,}7\ ^0C}{99{,}8\ ^0C} \cdot 100 = 0{,}7\%$$

f) How should we write the result of our experiment?

Temperature = (99,8 ± 0,7) ºC

g) Has it been a precise experiment?

Yes, as the relative error is lower than 1%

EXERCISES

13. Five people in your class have measured the height of one of your classmates and they have obtained these five different results:

1,65 m ; 1,57 m; 1,63 m; 1,67 m; 1,68 m;

a) What height will you take as the most likely?
b) What absolute error has made each of your classmates?
c) What is the average of that absolute error?
d) How will you write the final result of this experiment?
e) What relative error has been made?
f) Has it been a precise experiment?

14. Your partners have made a race, and you are helping with other 3 people to measure the time. For the first, you have measured the next times:

45,6 s; 47,5 s; 48,2 s; 43,1 s;

a) What time will you take as the most accurate?
b) What absolute error have you and your mates made?
c) What is the average of that absolute error?
d) How will you write the final result of the race?
e) What relative error has been made?
f) Has it been a precise experiment?

6. DATA ANALYSIS IN CHARTS AND GRAPHS.

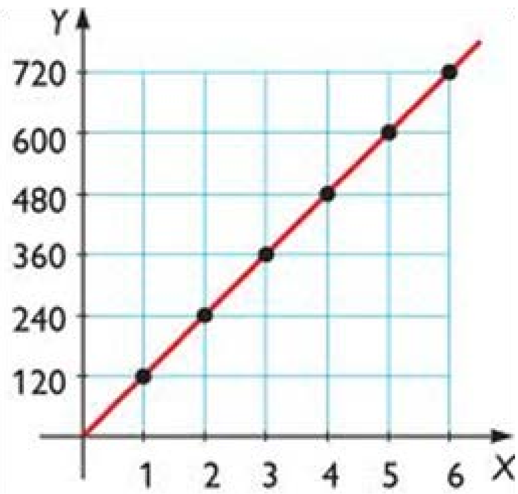
Once scientists have made their experiment and have taken measures, it is time to interpret those data so laws and theories can be made.

To organize and analyse data scientists use charts and graphs.

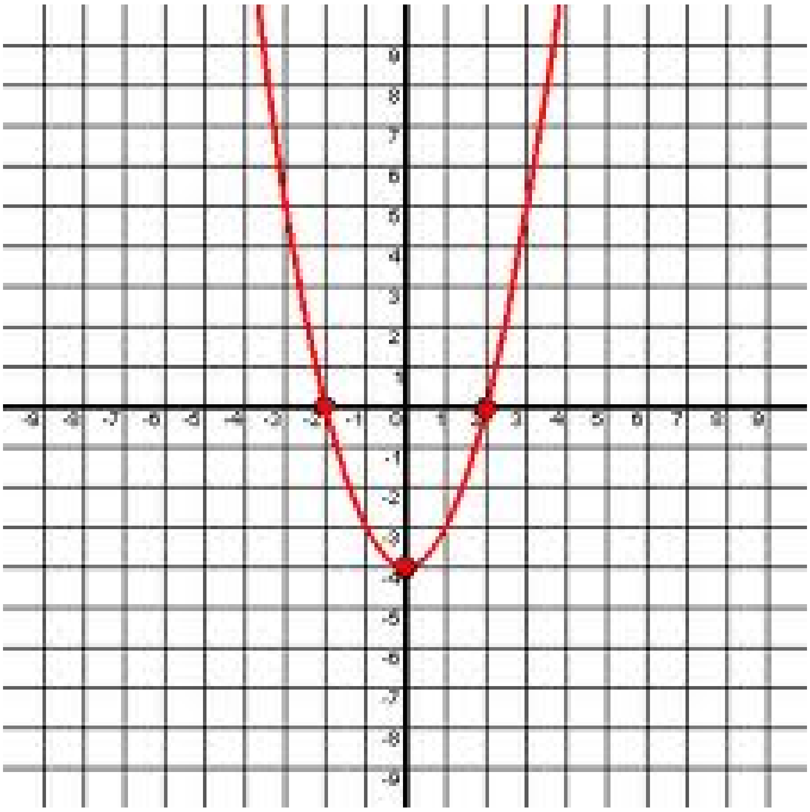
They also allow us to make predictions.

There are several types of graphs, this year we will see just the most important ones that are:

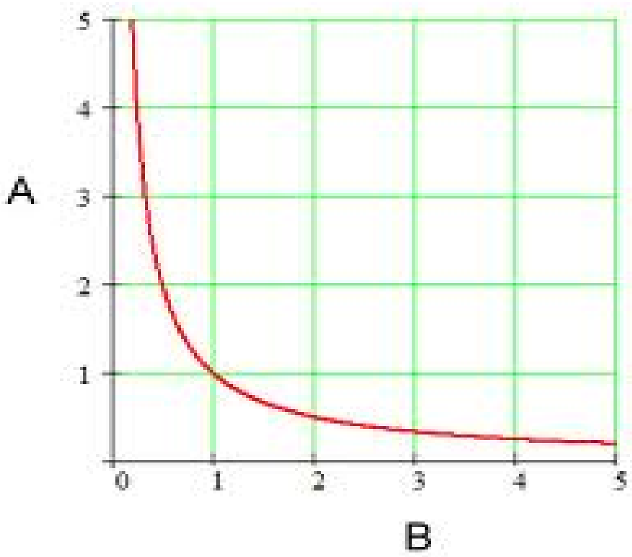
- Proportional graph: With the equation y = ax +b



– Quadratic graph: With the equation $y = ax^2 + b$



– Inverse proportion: It has the equation $y = 1/x$



We can see how it works in the next example:

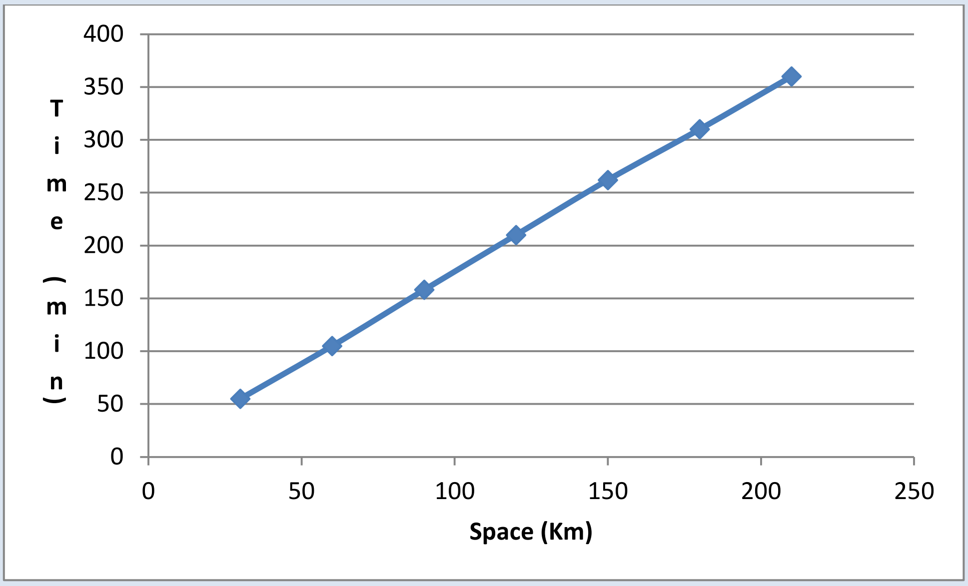
EXAMPLE:

Jesus is travelling in a car from Madrid to Valencia. To amuse himself he writes how many kilometres he makes every thirteen minutes. He made 7 measures: 55 km; 105 km; 158 km; 210 km; 262 km; 310 km; 360 km.

a) Made a chart with the results:

Time (min)	30	60	90	120	150	180	210
Space (km)	55	105	158	210	262	310	360

b) Draw a graph:



c) How many km had he made when he had travelled for 100 minutes?

If we follow the lines in the graph we can see that he had travelled 175 km. approximately.

d) What kind of function does it represents?

Proportional function

EXERCISES

15. A vehicle starts to move. Time and space are measured obtaining the next results:

Time (s)	0	2	3	4	5	6	7
Space (m)	0	20	45	80	125	180	245

a) Draw a graph with these data.

b) What kind of graph is it?

c) How many meters will have run at 10 seconds?

d) How much time will it take to run 300 meters?

16. In the laboratory, we have measured the pressure and the volume of a balloon, obtaining the next results:

Pressure (atm)	1	2	3	4	5
Volume (L)	5,00	2,50	1,67	1,25	1,00

a) Draw a graph with these data.

b) What kind of graph is it?

c) At what pressure the balloon will have a volume of 6 litres?

7. LEARNING SITUATION: MEASUREMENT ERRORS.

STUDY OF THE TIME INVERTED BY A BALL FALLING TROUGH A SLIDE

OBJECTIVES:

1. To measure the time that a ball uses to cover distances.
2. To calculate the average time used by the ball.
3. To calculate the error made in the measurements.
4. To decide if the experiment has been precise.
5. To draw a graph and identify the relation between time and space.

MATERIAL: BALL, SLIDE, CRONOMETER

ACTIVITY:

1. **Look at the chronometer:** What is its sensitivity?
2. **Measure the time** that the ball uses to cover three different distances and complete the following chart with the necessary calculations.

invested time in covering ___cm		invested time in covering ___cm		invested time in covering ___cm	
Experimental time (s)		**Experimental time (s)**		**Experimental time (s)**	
t_A		t_A		t_A	
t_B		t_B		t_B	
t_C		t_C		t_C	
t_D		t_D		t_D	
Average time		**Average time**		**Average time**	
Error in measured times (s)		**Error in measured times (s)**		**Error in measured times (s)**	
E_A		E_A		E_A	
E_B		E_B		E_B	
E_C		E_C		E_C	
E_D		E_D		E_D	
Absolute error		**Absolute error**		**Absolute error**	
Average time ± absolute error		**Average time ± absolute error**		**Average time ± absolute error**	
% relative error		**% relative error**		**% relative error**	

After doing the practice answer the next questions:

a) Observe the average error in which measurement had we made the biggest error?

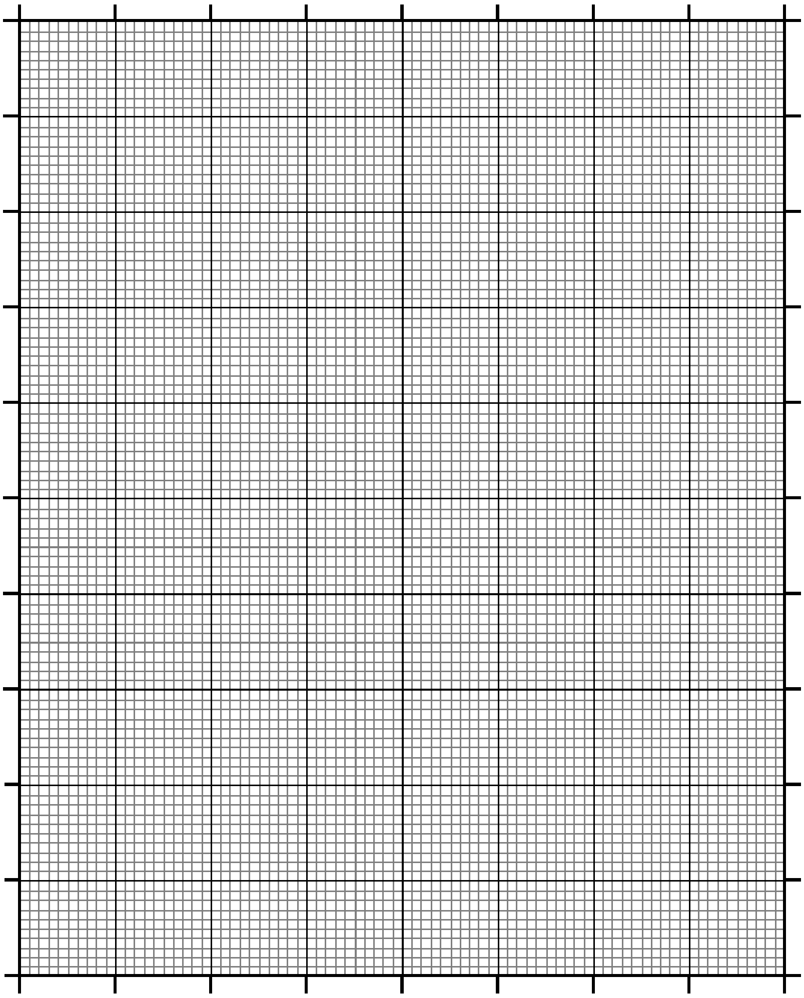
b) In which had we made the smallest error?

c) Based in questions a) and b), make a hypothesis, if it is possible, explaining the reasons.

d) Can our method be considered precise?

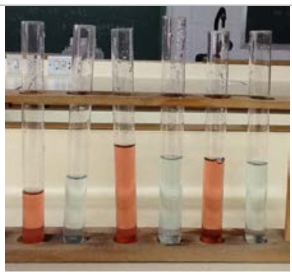
e) Draw a graph relating the distance and time and say what kind of function it represents.

f) Can you predict how much time the ball will invest to fall 100 cm?



8. WORKING IN THE LAB. LABORATORY MATERIAL

As a younger scientist, you need to know the names of laboratory materials that you will use for your experimental work. Pay attention and complete the following table:

			
It is called			
It is used for			
			
It is called			
It is used for			
			
It is called			
It is used for			

			
It is called			
It is used for			
			
It is called			
It is used for			

17. Now, write some sentences to explain the use of some of these materials.
    You can use the following type of sentences:

……. Is a	laboratory	material used for	verb-ing …..
	glass		
	separating		
	measuring		

18. Answer to the questions:
    b. What laboratory materials are used for measuring volume of substances?
    c. Is there any other volumetric material that isn´t on the table above? Draw it.

9. DEVELOPMENT OF A RESEARCH PROJECT.

Soon, you will have to develope your own research project. To face this new work, you need to bear in mind the steps of the scientific method that you have just learned in this unit. Let´s remember some interesting advice.

Firstly, do the background research looking into books or web pages the most important concepts, theories or laws related to your project. Remember to note down the used bibliography and web addresses. This information must be included in your final report.

Once you have clearly understood the theoretical bases of your work, you will be able to decide the goal of your project and to decide your hypothesis. Remember to be honest and evaluate the actual possibilities to develop your work and ask for your teacher´s opinion.

Carefully plan your experimental work, taking into account the materials and instruments you will need and the variables or magnitudes you will have to measure. Before developing the experimental work, revise your planning with your teacher.

Do your measurements carefully and accurately. Be patient and invest the time you need to develop your work as well as possible. Ask your teacher if you have any doubt and don´t forget he or she is your guide.

To order and analyze your data you can use a computer. Some spreadsheet programs, such as excel, draw the graph once you have included your numerical results. But before using it, try to draw first your graph by hand in order to understand how the program works.

Analyze conscientiously your results and get a conclusion. It can turn out to be difficult for you, so once more it is recommended to ask for your teacher's view.

And finally write your report; the following points must be included:

1. Title
2. The name of the components in the working group
3. The objectives of the experimental study. Infinitive tenses must be used, such as:

   "To investigate the properties of the matter".
4. A review of the theory related to the work that you have found in the bibliography.
5. Material used in the experimental work. Information about the sensitivity of the measuring devices and a drawing of the materials should be included.
6. Experimental work: you have to describe everything you did and observed during your experimental work. Use past tenses.
7. Charts and graphics with the measurement of magnitudes
8. Conclusion of your work.

10. LEARNING SITUATION: MEASURING THE DENSITY OF A SUBSTANCE.

OBJECTIVES:

1. To measure mass and volume in bodies.
2. To practice with two different methods of measuring the volume of solid objects.
3. To calculate density values using mass and volume experimental measurements.
4. To determine the error made in the calculation of the density of the substance-
5. To express the scientific expression of density.
6. To discuss about the precision of the method used to obtain the density of the substance.

MATERIAL: *GRADUATED CYLINDER, ELECTRONIC BALANCE, CALIBER, DIFFERET PIECES MADE OF THE SAME MATERIAL.*

Work in pairs or groups of three:

ASK A QUESTION:

Observe around and ask for the density of a substance in objects you use. Choose different objects that you think are made of the same material. Tell your teacher what objects you are going to use.

BACKGROUND RESEARCH

Look information about how you can get the density of a body and describe the process in detail.

PLAN YOUR EXPERIMENTATION

Think about what material do you need and plan your experiment.

PERFORM YOUR EXPERIMENTATION AND ANALIZE YOUR DATA

Measure magnitudes, note down their values on a table and calculate the density of each body.

CONCLUSION

Answer the following questions:

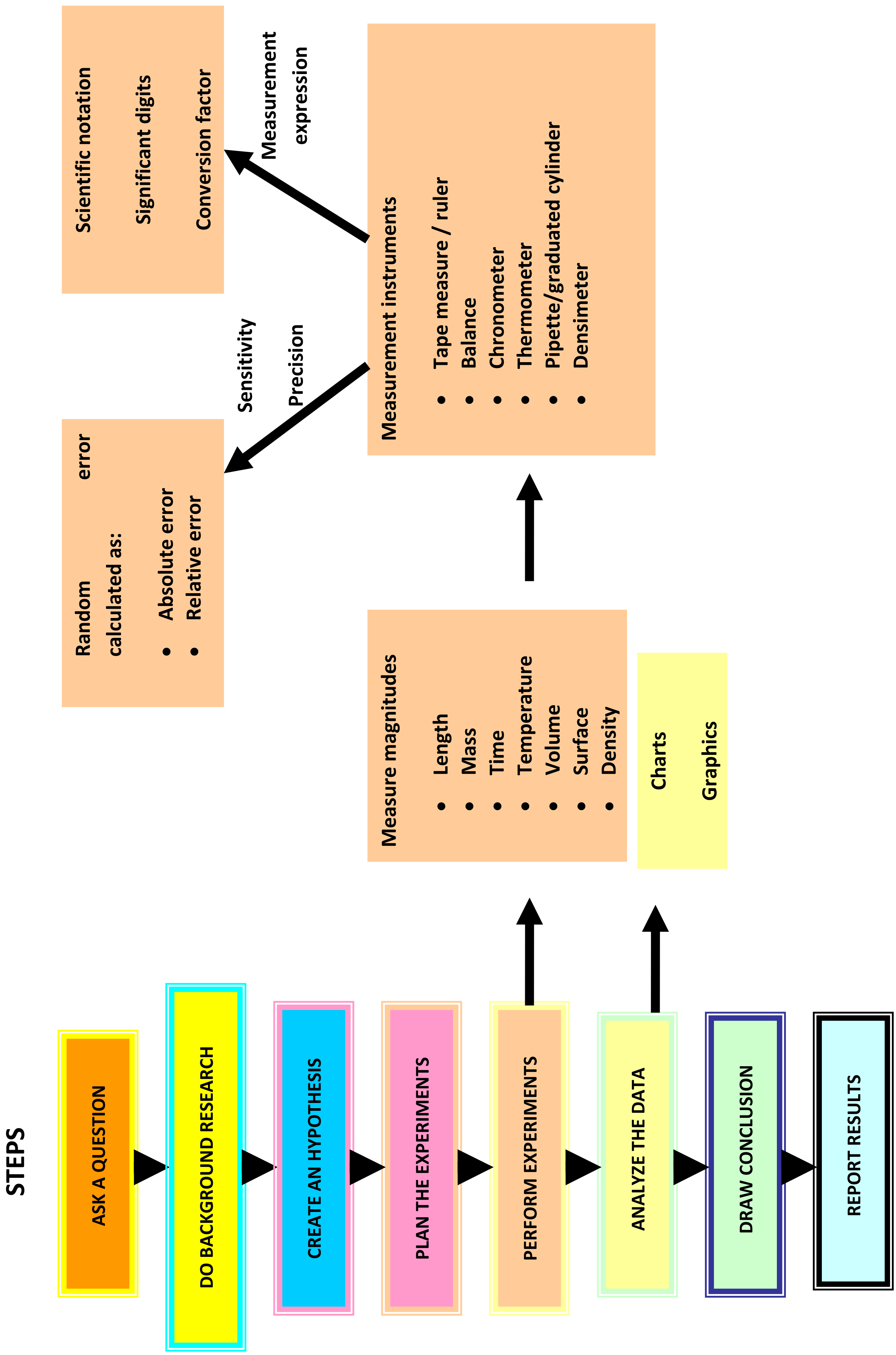
- Are your bodies made of the same substance?
- What substance are your bodies made of?

- What is the scientific expression of the density you have calculated?
- Is your method precise?

WRITE A REPORT

Make a power point presentation about your experimentation, showing all the steps you have followed in your research.

10. VOCABULARY REVIEW



11.FINAL ACTIVITIES

19. Make the following change of units and express in scientific notation:

- a) 108 km/h to m/s
- b) 42300 pm to km
- c) 57 dam^2 to km^2
- d) 72 m^3 to ℓ
- e) 200 m/s to km/h
- f) 5,6 g/cm^3 to kg/m^3
- g) 580 dm^3 to dam^3
- h) 200 nm to m
- i) 36 ℓ to cm^3
- j) 84 dm^2 to mm^2

20. Express the next measurements in the International System of units, using scientific notation:

- a) 442 km
- b) 387 ℓ
- c) 25 nm
- d) 476 mm^3
- e) 342 μg
- f) 120 km/h
- g) 40 g/ℓ
- h) 340 kg/ℓ

21. Rewrite the next measurements into the International System of units:

- a) 27 inch
- b) 35 ft
- c) 500 yd
- d) 300 min
- e) 3 pt
- f) 50 oz
- g) 35 lb.
- h) 35 mph (miles/hour)

22. In English-speaking countries, a person height is measured using feet and inches. Express your height in that system.

23. In English-speaking countries, the weight of a person is measured using pounds. If somebody has a weight of 60 kg, what would be his weight in pounds?

24. Convert and use scientific notation:

- a) 57 km to μm
- b) 157 mg to Mg
- c) 639 hours to minutes
- d) 25 nm to pm
- h) 388 μg to kg
- i) 35 mm to dam
- j) 3589 Mm to Tm
- k) 4500 pm to m

e) 25000 ns to minutes

f) 27 years to hours

g) 2,32 g/cm^3 to kg/m^3

l) 273 Gg to g

m) 450000 ns to min

n) 40 µs to s

25. Rewrite the next numbers using scientific notation and using two decimals behind the coma:

a) 3454500000

b) 0,0000034562

c) 324600

d) 3103000

e) 0,00000000000003

f) 0,00456

g) 2334000000000000000

26. Rewrite this numbers to decimal notation:

a) $3,5 \cdot 10^{-8}$

b) $4,76 \cdot 10^{3}$

c) $9 \cdot 10^{-9}$

d) $4,47 \cdot 10^{5}$

27. Five people in your class have measured the length of their table and they have obtained the following results:

34,5 cm; 34,2 cm; 35,1 cm; 34,9 cm; 36,0 cm

a) What length should be taken as the most accurate?

b) What absolute error has made each of your classmates?

c) What is the average of that absolute error?

d) How will you write the final result of this experiment?

28. You are weighting in an old (non digital) scale. As it is not very accurate, you take four different results:

61,3 kg; 60,9 kg; 62,0 kg; 61,8 kg

a) What do you think is your weight?

b) What absolute error have you made in each measure?

c) What is the average of that absolute error?

d) How will you write your weight?

In the lab, we measure the volume and temperature of a balloon, obtaining the next results:

Volume (ℓ)	0,5	0,53	0,55	0,59
Temperature (K)	293	313	323	343

a) Draw a graph with these data.

b) What kind of graph is it?

c) If the balloon explodes when its volume it's 0,6 ℓ, at what temperature will it happen?

30. Measuring force and acceleration in a moving object we obtain the following data:

Force (N)	10	20	30	40
Acceleration (m/s^2)	2	4	6	8

a) Draw a graph with these data.

b) What kind of graph is it?

c) Which force will produce an acceleration of 5 m/s^2 in the object?

How much have you learnt?

31. Classify and order the following nouns in the chart below and complete it with the information you know:

Metre, surface, volume, litre, microgram, time, temperature, Kelvin, squared decametre, kilometre per hour, kilogram, decilitre, Celsius degree, rate, cubic metre.

Fundamental magnitude	**Derived magnitude**	**International System Unit**	**Other units**	**Measuring instrument**

32. Make the following change of units and express the result in scientific notation :

a. 3267 Mm to dam

b. 234 mm^2 to hm^2

c. 4213 cm^3 to dam^3

d. 567 mm^3 to daℓ

e. 0,034 kℓ to cm^3

f. 130 km/h to m/s

g. 220 dam/min to m/s

h. 33 dam/min to km/h

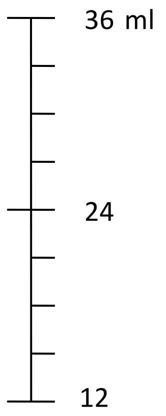
i. 458 kg/m^3 to g/cm^3

j. 4,2 g/cm^3 to kg/m^3

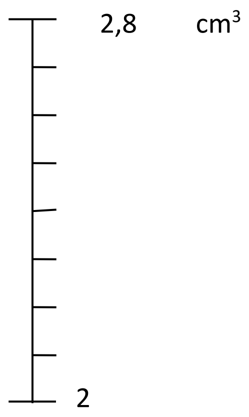
k. 31 cg/mm^3 to kg/m^3

33. Decide which is the sensitivity of the following measuring instruments:

A graduated cylinder with the scale:



A pipette with the scale:



A balance that measures 32,23g

A stopwatch that measures: 2,34s and 2,36s.

34. Underline the significant figures in the following measurements:

a. 0,03207 mm

b. 34000 km

c. 230 hg

d. 3,450 g

35. Measuring the volume of a metal piece, the following values were found:

34,25 cm^3, 34,27 cm^3, 34,30 cm^3

Calculate:

a. the average volume measurement

b. the absolute error in the measurements

c. the relative error of the measurement

d. the sensitivity of the measuring instrument

e. is this measuring method precise?

36. The density of a substance was measured, and it resulted: 2,12 ± 0,03 g/cm^3 What does this expression mean?