

Program

Physics/Biophysics Level : First Year

1. Solution biophysics
2. Electricity
3. Geometric optics
4. Radiation biophysics

Who is the best, Zinedine Zidane or Michael Jackson !!!!!?

Who is stronger, an elephant or a bond ?

Which is the best rating 19/20 or 95/100 ?

Mathematical Reminders

1. Physical Quantities and Units
2. Error Calculation

Mathematical Reminders

1. Physical quantities and units

a. Definition :

Physics studies the laws of material and natural phenomena in the world around us.

Like any other science, physics has as its essential objective the discovery and study of these laws.

Examples

- The view
- Hearing
- Heartbeats
- The wind
- The rain
- The earth movement

Physics is an exact science where laws are expressed by mathematical formulas.

To describe these laws, physics uses the notions of physical quantities.

Physical Quantities

Scalar: a quantity whose value depends only on the point at which it is evaluated. It is reduced to a numerical value and the measurement unit.

Examples:

- The mass
- The volume
- The surface
- The density

Vector: a quantity that is characterized by a direction, a sense, a module and a application point.

Examples:

- Speed
- The force
- The pressure
- The electric field

b. Significant figures

The number of figures in a measured or calculated value gives an indication of the precision of the measurement or calculation.

The notion of a significant figure is specific to scientists who handle experimental quantities which are always tainted by a certain uncertainty linked to the measurement.

Rules for determining the number of significant figures in a value:

All figures from 1 to 9 in a number are considered significant.

Example

❑ How many significant figures does the number 235.48 has?

❑ The number 235.48 has 5 significant figures : 2, 3, 5, 4, 8

Zeros after the figures of a number (on the right) are considered significant.

Example

❑ How many significant figures does the number 235.4800 has?

❑ The number 235.4800 has 7 significant figures : 2, 3, 5, 4, 8, 0, 0

Zeros between figures of a number are considered significant.

Example

❑ How many significant figures does the number 2305.048 has?

❑ The number 2305.048 has 7 significant figures : 2, 3, 0, 5, 0, 4, 8

Zeros at the beginning of the figures of a number (on the left) are not considered significant.

Examples

❑ How many significant figures does the number 0235.48 has?

❑ The number 0235.48 has 5 significant figures : 2, 3, 5, 4, 8

❑ How many significant figures does the number 0.0023 has?

❑ The number 0.0023 has 2 significant figures : 2 and 3

When a value is expressed in scientific notation with a power of 10, all figures in front of the power of 10 are significant: the power of 10 is not taken into account in the counting of significant figures.

Example

❑ How many significant figures does the number 235.48×10^4 has?

❑ The number 235.48×10^4 has 5 significant figures : 2, 3, 5, 4, 8

Determine the number of significant figures in simple operations

Addition and Subtraction

The method to write the result is as follows:

1. Identify the least precise term: this will be the term with the fewest decimal places (fewer figures after the decimal point) ;
2. Remember the number of decimal places;
3. Perform the addition or subtraction operation;
4. Round the result of the operation to the same number as identified in step 2.

Example

❑ What is the result of: $256.3 + 1.89$

Solution :

1. Identify the least precise term:
the number 256.3 has one figure after the decimal point
the number 1.89 has two figures after the decimal point
So the least precise number is **256.3** .
2. Remember the number of decimal places: **256.3 has a decimal place ;**
3. Perform the addition operation: = **258.19**
4. Round the result of the operation to the same number as that identified in step 2:
The result of the addition is 258.2

❑ What is the result of: $256.3 - 1.89$

Solution :

1. Identify the least precise term:

the number 256.3 has one figure after the decimal point

the number 1.89 has two figures after the decimal point

So the least precise number is **256.3**.

2. Remember the number of decimal places: **256.3 has a decimal place ;**

3. Perform the subtraction operation: = **254.41**

4. Round the result of the operation to the same number as that identified in step 2:

The result of the subtraction is 254.4

Multiplication and Division

The method to write the result is as follows:

1. Determine the number of significant figures in each term of the calculation ;
2. Identify among the terms of the calculation the one with the fewest significant figures. The result will then have the same number of significant figures as the latter ;
3. Perform the operation ;
4. Round the result of the operation to the same number of significant figures determined in step 2.

Examples

❑ What is the result of: $256.3 * 1.89$

Solution :

1. Determine the number of significant figures :
the number 256.3 has 4 significant figures
the number 1.89 has 3 significant figures
2. So the number with the fewest significant figures is **1.89**
- 3 . Perform the multiplication operation: = **484.407**
4. Round the result of the operation to the same number as that identified in step 2:
The result of the multiplication is 484

❑ What is the result of: $2.689 * 3.6 * 10^5$

Solution :

1. Determine the number of significant figures :

the number 2.689 has 4 significant figures

the number $3.6 * 10^5$ has 2 significant figures

2. So the number with the fewest significant figures is **$3.6 * 10^5$**

3 . Perform the multiplication operation: = **968040**

4. Round the result of the operation to the same number as that identified in step 2:

The result of the multiplication is $9.7 * 10^5$

❑ What is the result of: $500/100$

Solution :

1. Determine the number of significant figures :

the number 500 has 3 significant figures

the number 100 has 3 significant figures

2. So the number with the fewest significant figures is **500 or 100**

3 . Perform the multiplication operation: = **5**

4. Round the result of the operation to the same number as that identified in step 2:

The result of the multiplication is 5.00

C. Physical Quantities

The measurement of certain physical quantities requires the use of a **STANDARD** .

The standards of physical quantities must not vary either over time or during measurement.

Any physical quantity having a standard to measure it is said

Fundamental Quantity

Examples

- ☐ The distance
- ☐ The time
- ☐ The mass

Any physical quantity that does not have a standard to measure it is said

Derived Quantity

Examples

- ☐ The speed
- ☐ The force
- ☐ The pressure

D. System International of Units (SI)

All definitions, measurement methods and units of physical quantities constitute
System of Units

The most used system of units is called
The System International (SI)

The fundamental units of the system international (SI) are:

<i>Units</i>	<i>Dimension</i>	<i>Unit in SI</i>
Length	L	Meter (m)
Mass	M	Kilogram (Kg)
Time	T	Second (S)
Electric current intensity	I	Ampere (A)
Thermodynamic temperature	θ	Kelvin (K)
Quantity of matter	μ or N	Mole (mol)
Light intensity	J	Candela (cd)

Plus two other units which are:

<i>Units</i>	<i>Dimension</i>	<i>Unit in SI</i>
Plane angle	α	Radian (rd)
Solid angle	Ω	Steradian (sr)

Other units which are not fundamental are called
Derived Units

Some derived units have units with a specific name.

Examples

<i>Derived units</i>	<i>Unit in SI</i>	<i>Unit in units of fundamental quantities of the SI</i>
Frequency	Hertz (Hz)	S^{-1}
Strength	Newton (N)	$m.Kg.S^{-2}$
Work	Joul (J)	$m^2.Kg.S^{-2}$
Energy	Joul (J)	$m^2.Kg.S^{-2}$
Pressure	Pascal (Pa = Nm^{-2})	$m^{-1}.Kg.S^{-2}$
Electric potential difference	Volt ($V = WA^{-1}$)	$m^2.kg.S^{-3}.A^{-1}$
Power	Watt (W)	$m^2.kg.S^{-3}$

Some derived units have units but do not have a specific name.

Examples

<i>Derived units</i>	<i>Unit in SI</i>	<i>Unit in units of fundamental quantities of the SI</i>
Surface (area)	Meter.meter (m^2)	m^2
Viscosity	Pascal. Second (Pa.S)	$\text{m}^{-1} \cdot \text{Kg} \cdot \text{S}^{-1}$
Surface tension	Newton per meter (N/m)	$\text{Kg} \cdot \text{S}^{-2}$
Electric field	Volt per meter (V/m)	$\text{m} \cdot \text{Kg} \cdot \text{S}^{-3} \cdot \text{A}^{-1}$
Mass entropy	Joul/kilogram.Kelvin ($\text{J} \cdot \text{Kg}^{-1} \cdot \text{K}^{-1}$)	$\text{m}^2 \cdot \text{S}^{-2} \cdot \text{K}^{-1}$

Other units whose value is obtained experimentally.

Examples

<i>Name</i>	<i>Symbol</i>	<i>Value in SI units</i>
Electron-volt	eV	1 eV = $1.06021773349 \cdot 10^{-19}$ J
Calorie	Cal	1 cal = 4.184 J
Atomic mass unit	u	1 u = $1.660540210 \cdot 10^{-27}$ Kg
Astronomical unit	ua	1 au = $1.4959787069130 \cdot 10^{11}$ m
Horse-hour (power produced by a horse during 1 hour)	Ch-h	1 ch -h = 2647900 J

Reminder: Prefixes for decimal multiples and submultiples of SI units have been defined

Examples

<i>Postman</i>	<i>Prefix</i>	<i>Symbol</i>	<i>Postman</i>	<i>Prefix</i>	<i>Symbol</i>
10^{24}	Yotta	Y	10^{-1}	Deci	d
10^{21}	Zetta	Z	10^{-2}	Centi	c
10^{18}	Exa	E	10^{-3}	Milli	m
10^{15}	Peta	P	10^{-6}	Micro	μ
10^{12}	Tera	T	10^{-9}	Nano	n
10^9	Giga	G	10^{-12}	Pico	p
10^6	Mega	M	10^{-15}	Femto	f
10^3	Kilo	K	10^{-18}	Atto	a
10^2	Hecto	h	10^{-21}	Zepto	z
10^1	Deca	da	10^{-24}	yocto	y

E. Dimensional Analysis

In SI, any physical quantity **G** can be expressed in terms of the fundamental units :

$$[G] = L^a \cdot M^b \cdot T^c \cdot I^d \cdot \theta^e \cdot \mu^f \cdot J^j$$

Which is the dimensional equation of the quantity G

Example : What are the dimensions of : Length ; speed ; acceleration and pressure ?

F. Homogeneity of a result

Any non-homogeneous result, from the point of view of dimensional analysis, is necessarily false.

On the other hand, a homogeneous result, from the point of view of dimensional analysis, is not necessarily correct.

Rules of homogeneity

- Only homogeneous terms can be added;

Examples

❑ $E_c + E_p = E_m$

❑ $m = F/a - nM$

- The argument of a transcendental mathematical function (exp , ln, cos, sin, tan, . .) is necessarily dimensionless;

Examples

❑ $[\text{Exp} (t/ \tau)] = 1$

❑ $[\log(x)] = 1$

- We must avoid replacing the symbol of a quantity with its numerical value;

Examples

❑ Write $P = m * g$ instead of writing $P = m * 9.81$

- A vector quantity is only equal to a vector quantity and not a scalar quantity ;

Examples

❑ Pressure (P) = F/S (P and F are vector quantities and S is a scalar quantity.

Example : Check the homogeneity of the equations: $E = mc^2$ and $E = cm^2$ and $E = 4mc^2$

G. Change of system of quantities

To write the dimensional equation of a physical quantity in a system other than SI, we proceed as follows:

- Write the dimensional equation of the quantity G in the SI and in the new system with unknown exponents;
- Write the dimensional equations of all the quantities of the new system in the SI;
- Determine the unknowns by dimensional analysis while respecting the homogeneity of the expressions;
- Write the dimensional equation of G in the new system of units.

Example : Suppose that we take as fundamental quantities the force (F), the density (ρ) and the frequency (N). Write the dimensional equation of the length in the system: $F\rho N$?