الجمهورية الجزائرية الديمقراطية الشعبية
République Algérienne Démocratique et Populaire

Ministère de l'Enseignement Supérieur
et de la Recherche Scientifique
Université Akli Mohand Oulhadj - Bouira -
Tasdawit Akli Muḥend Ulḥağ - Tubirett -
Faculté des Sciences de la Nature
et de la Vie et des Sciences de la Terre

وزارة التعليم العالي والبحث العلمي
جامعة أكلي محند أولحاج
- البويرة -
كلية علوم الطبيعة والحياة وعلوم الأرض

Physics Course Handout

Intended for students in the 1st year of the Bachelor's degree

Mars 2025

Dr REKAB DJABRI Hamza

Content of the subject

Chapiter VI: Concept of Crystallography

Introduction

Introduction to the Physics Course for First-Year Biological Science Students

Physics is a fundamental science that provides the basis for understanding the natural world by exploring the principles governing matter, energy, and their interactions. This course is designed for first-year students in the Common Core of Biological Sciences, following the official curriculum set by the Ministry of Education. It aims to equip students with essential physics concepts relevant to their field of study, emphasizing problem- solving skills and practical applications.

The course is structured into four comprehensive chapters, each addressing a key area of physics:

Chapter 1: Mathematical Remender in Physics

This chapter introduces essential mathematical tools for analyzing physical problems and consists of three main sections:

- *Dimensional Analysis:* A powerful method for verifying equations, ensuring the consistency of physical expressions, and understanding the relationships between different physical quantities.
- *Vector Analysis:* A crucial topic for understanding physical quantities that have both magnitude and direction, which is essential in various branches of physics, including the different of products (scalare and vectorial prodects).
- *Errors and Incertainty:* This section explores the conditions under which physical systems reach a state of balance, laying the foundation for future studies in mechanics and fluid dynamics.

Chapter 2: Geometrical Optics

Light plays a crucial role in both physics and biological sciences. This chapter covers fundamental principles of geometrical optics, including:

- *Descartes' Laws of Reflection and Refraction:* These laws govern how light interacts with different surfaces and materials, forming the basis for optical studies.
- *Lenses and Mirrors:* Understanding image formation through convex and concave lenses and mirrors, which is essential in vision science, microscopy, and optical instruments.
- *Prisms:* Exploration of light dispersion and color separation using prisms, which has applications in spectroscopy and optical analysis.

Chapter 3: Fluid Mechanics

Fluids are a vital component of biological systems, from blood circulation to respiratory processes. This chapter covers:

- *Fluid Statics:* Concepts such as pressure, buoyancy, and Pascal's and Archimedes' principles.
- *Fluid Dynamics:* Key topics include Bernoulli's equation, viscosity, and laminar versus turbulent flow. These concepts are crucial for understanding biological fluid transport mechanisms.

Chapter 4: Concept of Crystallography

This chapter introduces crystallography, an essential field in materials science, chemistry, and biology. It provides an overview of:

- Crystal Structures and Properties: Understanding how atomic arrangements influence material properties.
- X-ray Diffraction and Applications: Exploring how crystallographic techniques are used to study molecular structures, including DNA and protein structures. To enhance understanding, this course includes detailed lessons, worked-out examples, problem sets, and laboratory exercises. These components help students apply theoretical knowledge to practical scenarios, fostering scientific reasoning and analytical skills. By the end of this course, students will have a solid foundation in physics, preparing them for advanced studies in biological sciences and related fields.

Chapter I: Mathematical Reminders

Objectif général:

One of the key steps in the process of mathematical modeling is to determine the relation ship between the variables. Considering the dimensions of those quantities can be useful when determining such relationship. Dimensional analysis is a method for helping determine how variables are related and for simplifying a mathematical model. Dimensional analysis alone does not give the exact form of an equation, but it can lead to a significant reduction of the number of variables. The objective of this part is to introduce clear definitions and appropriate notations.

Learning objective:

After going through this chapter, students will be able to;
- understand physical quantities, fundamental and derived;
- describe different systems of units;
- define dimensions and formulate dimensional formulae;
- write dimensionalequations and apply these to verify various formulations.

-Know the different types of errors**.**

"It is better to be roughly right than precisely wrong." — Alan Greenspan

I. Mathematical reminders

I.1. Dimensions and units

A dimension is a measure of a physical quantity (without numerical values), while a unit is a way to assign a number to that dimension. For example, length is a dimension that is measured in units such as microns (m), feet (ft), centimeters (cm), meters (m), kilometers (km), etc. (Fig. 1).

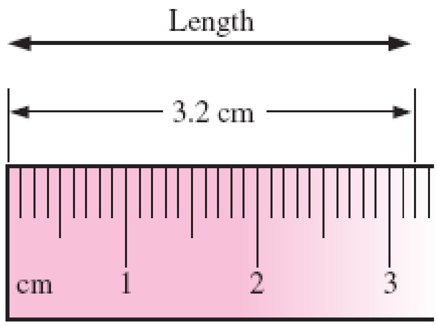


Fig. 1 [3]

A dimension is a measure of a physical quantity without numerical values, while a unit is a way to assign a number to the dimension. For example, length is a dimension, but centimeter is a unit.

There are seven primary dimensions (also called fundamental or basic dimensions)—mass, length, time, temperature, electric current, amount of light, and amount of matter.

Dimension	SI Unit	English Unit
Mass M	**kg (kilogram)**	**lbm (pound-mass)**
Length L	**m (meter)**	**ft (foot)**
Time T	**s (second)**	**s (second)**
Temperature θ	**K (kelvin)**	**R (rankine)**
Amount of matter N	**mol (mole)**	**mol (mole)**
Electric current I	**A (ampere)**	**A (ampere)**
Amount of light C	**cd (candela)**	**cd (candela)**

Primary dimensions and their associated primary SI and English units

We shall refer to the dimension of the base quantity by the quantity itself, for example

dim length ≡ length ≡ L, dim mass ≡ mass ≡ M, dim time ≡ time ≡ T.

Mechanics is based on just the first three of these quantities, the MKS or meterkilogram-second system. An alternative metric system to this, still widely used, is the socalled CGS system (centimeter-gram-second).

I.2 Dimensions of Derived Quantities:

The dimensions of common derived mechanical quantities are given in the following table.

Quantity		**Dimension**	**MKS unit**
Area	**A**	L^2	m^2
Volume	**V**	L^3	m^3
Velocity	**v**	$L.T^{-1}$	**m/s**
Frequency	**f**	T^{-1}	s^{-1} = hertz = Hz
Angle	**α, β, ...**	**radian**	**rad**
Angular velocity	**ω**	T^{-1}	$rad \cdot s^{-1}$
Acceleration	**a**	$L.T^{-2}$	$m.s^{-2}$
Viscosity	**μ**	$M.L^{-1}.T^{-1}$	$Kg\ m^{-1}s^{-1}$
Density	**ρ**	$M.L^{-3}$	kg/m^3
Force	**F**	$M.L.T^{-2}$	$N=kg \cdot m \cdot s^{-2}$
Energy, work, heat	**E,W**	$M.L^{2}.T^{-2}$	$J=kg \cdot m^2 \cdot s^{-2}$
Power	**P**	$M.L^{2}.T^{-3}$	$W=kg \cdot m^2 \cdot s^{-3}$
Pressure	**p**	$M.L^{-1}.T^{-2}$	$Pa=kg \cdot m^{-1} \cdot s^{-2}$

Some important abbreviations

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

I.3 Dimensional homogeneity :

We've all heard the old saying; you can't add apples and oranges (Fig. 2). This is actually a simplified expression of a far more global and fundamental mathematical law for equations, the law of dimensional homogeneity, stated as

Every additive term in an equation must have the same dimensions.

If the power of M, L and T on two sides of the given equation are same, then the physical equation is correct otherwise not. Therefore, this principle is very helpful to check the correctness of a physical equation.

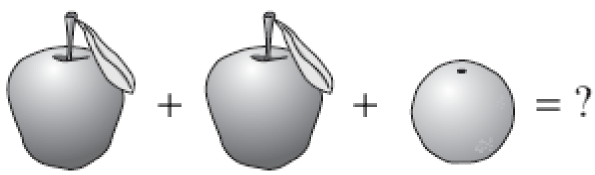


Fig. 2:You can't add apples and oranges! [3]

Example:

Probably the most well-known (and most misused) equation in fluid mechanics is the Bernoulli equation discussed in Chap. 2. The standard form of the Bernoulli equation for incompressible irrotational fluid flow is:

$$P + \rho\, gz + \frac{1}{2}\, \rho v^2 \; = Cste \quad \text{..........1}$$

(a) Verify that each additive term in the Bernoulli equation has the same dimensions.

(b) What are the dimensions of the constant C?

Solution:

We are to verify that the primary dimensions of each additive term in Eq. 1 are the same, and we are to determine the dimensions of constant C.

Analysis (a) Each term is written in terms of primary dimensions,

Pressure :$[P]=M.L^{-1}.T^{-2}$

$\frac{1}{2}\rho v^2=M.L^{-3}.L^{2}.T^{-2}=M.\,L^{-1}.T^{-2}$

$\rho gz= M.L^{-3}.L.\,T^{-2}.L=M.\,L^{-1}.T^{-2}$

Indeed, all three additive terms have the same dimensions.

(b) From the law of dimensional homogeneity, the constant must have thesame dimensions as the other additive terms in the equation. Thus, Primary dimensions of the Bernoulli constant:

$[C]= M.\,L^{-1}.T^{-2}$

Discussion: If the dimensions of any of the terms were different from the others, it would indicate that an error was made somewhere in the analysis.

a. Use of dimensional analysis to "predict" the expression of a physical quantity:

The method consists in identifying the physical quantities which can influence this quantity, and in constructing with these quantities an expression having the desired dimension (i.e. that of the quantity considered).

Example:

The period of oscillation T of a mass m suspended at the end of a spring of stiffness k is written:

$T = a\ m^x\ k^y$. Where: a is a dimensionless constant. Find the expression for the period.
We have F=KX, $[K]=MT^{-2}$
$T = a\ m^x\ k^y \rightarrow [T] = [m^x][k^y] \rightarrow T = M^x(MT^{-2})^y$
We compare part 1 with 2 of the equation:

$$\begin{cases} x + y = 0 \\ -2y = 1 \end{cases} \Rightarrow \begin{cases} y = -\dfrac{1}{2} \\ x = \dfrac{1}{2} \end{cases}$$

$$T = a\sqrt{\frac{m}{k}}$$

b.convert a physical quantity from one system of units into another.:

The relationships between the units of the different systems can be easily established using the dimensional equations.

Example:

Calculate the relationship between the Barye (unit of pressure in the CGS system) andthe pascal (unit of pressure in the S. I.)

Pressure : $[P] = \mathrm{M.L^{-1}.T^{-2}}$

$\frac{1Pa}{1Baraye} = \left(\frac{M}{M}\right)\left(\frac{L^{-1}}{L^{-1}}\right)\left(\frac{T^{-2}}{T^{-2}}\right) = \frac{1000}{1}.\frac{100^{-1}}{1}.\frac{1}{1} = 10$ (3)

⇒1Pa=10 Baraye

Errors, precision and accuracy: why study them?

People in scientific and technological professions are regularly required to give quantitativeanswers. How long? How heavy? How loud? What force? What field? Their (and your) answers to such questions should include the value and an error. Measurements, values plotted on graphs, values determined from calculations: all should tell us how confident you are in the value. In the Physics Laboratories, you will acquire skills in analysing and determining errors. These skills will become automatic and will be valuable to you in almost any career related to science and technology. Error analysis is quite a sophisticated science. In the First Year Laboratory, we shall introduce only relatively simple techniques, but we expect you to use them in virtually all measurements and analysis.

What are errors?

Errors are a measure of the lack of certainty in a value.

$$\text{Measurement} = (\text{best estimate} \pm \text{uncertainty}) \text{ units}$$

For example, if we measure the distance between two points on a track with a ruler having millimeter division on it, we may record our measurement as

$$\text{Distance} = (2.5 \pm 0.1)\ \text{cm}$$

The significance of ± 0.1 cm is that when we repeat our measurement several more times, thereadings we obtain are expected to be one of the values 2.4 cm, 2.5 cm, or 2.6 cm. For many repetitions of the measurement, the value most frequently occurring will be the value 2.5 cm.

Note that all readings require both a number and a unit.

Sources of Errors

Sources of error, other than the inability of a piece of hardware to provide true measurements, are as under:

1. Insufficient knowledge of process parameters and design conditions
2. Errors caused by person operating the instrument
3. Change in process parameters, irregularities, etc.
4. Poor maintenance
5. Poor design
6. Certain design limitations

Absolute Error:

Absolute error is defined as the magnitude of difference between the actual and the approximated values of any quantity. For example, we measure a given quantity n times and a_1 , a_2 , a_3 , … a_n are the individual values. Then the arithmetic mean (say a_m) can be found as

$$a_m = \frac{a_1 + a_2 + \cdots + a_n}{n}$$

The absolute error can now be obtained from the following formula:

$$\Delta a_n = a_m - a_n$$

In simple words, absolute error is the amount of physical error in a measurement. If we use a metre stick to measure a given distance, then the error may be ±1 mm or ±0.001 m. This is the absolute error of the measurement. For the measurement of a quantity x, the absolute error is Δx.

Relative Error:

Relative error gives us an idea of how good a measurement is relative to the size of the object being measured, For example, we measure the height of a room and the length of a small table by using a metre stick. We find the height of the room as 3.256 m ± 1 mm and the length of the table as 0.082 m ± 1 mm. Then

$$\textbf{Relative error} = \frac{\textbf{Absolute Error}}{\textbf{Valueofthingmeasured}}$$

Relative error in measuring the height of the room

$= \frac{0.001}{3.256} = 0.0003$

Relative error in measuring the length of the table

$= \frac{0.001}{0.082} = 0.0122$

Here, it is clear that the relative error in measuring the length of the table is larger than the relative error in measuring the height of the room. In both the cases, however, the absolute error is the same

If the relative error is represented in percent, then the error is called percentage error. For example, in the above example, the percentage error in measuring the height of the room is 0.0003 * 100 = 0.03%, while the percentage error in measuring the length of the table is 0.0122 * 100 = 1.22%.

Errors occurring in arithmetic operations

a-Addition and Subtraction

Let us consider two measured values $a \pm \Delta a$ and $b \pm \Delta b$ in which a and b are actual values, whereas Δa and Δb are absolute errors of a and b respectively.

The error obtained in the sum of these quantities is given by

$$Q \pm \Delta Q = (a \pm \Delta a) + (b \pm \Delta b)$$

$$= (a + b) + (\pm\Delta a \pm \Delta b)$$

$$\Rightarrow \Delta Q = \Delta a + \Delta b$$

Similarly, the error obtained in their difference is given by

$$Q \pm \Delta Q = (a \pm \Delta a) - (b \pm \Delta b)$$

$$= (a - b) + (\pm\Delta a \pm \Delta b)$$

$$\Rightarrow \Delta Q = \Delta a + \Delta b$$

Hence, in arithmetic operations of addition and subtraction, the absolute error in the resultant is the sum of the absolute errors of individual quantities. So errors are always added in these operations.

b-Multiplication and Division

Let us consider a quantity G depending on other quantities x, y, z, i.e. G = f(x,y,z). The error committed on this quantity, ΔG, can be expressed as a function of the absolute errors Δx,Δy ,Δz by applying one of the following methods:

***Total differential method:**

In order to calculate the error ΔG:

*We take the total differential of G

$$dG = \left|\frac{\partial f}{\partial x}\right| dx + \left|\frac{\partial f}{\partial y}\right| dy + \left|\frac{\partial f}{\partial z}\right| dz$$

*We replace the differentials dx, dy, dz by the absolute errors Δx, Δy, Δz and we take the absolute values of the partial derivatives

$$\Delta G = \left|\frac{\partial f}{\partial x}\right| \Delta x + \left|\frac{\partial f}{\partial y}\right| \Delta y + \left|\frac{\partial f}{\partial z}\right| \Delta z$$

Example :

$$E = \frac{1}{2} m v^2$$

$$dE = \left|\frac{\partial E}{\partial m}\right| dm + \left|\frac{\partial E}{\partial v}\right| dv$$

$$dE = \frac{1}{2} v^2 dm + mvdv$$

$$\Delta E = \frac{1}{2} v^2 \Delta m + mv\Delta v$$

$$\frac{\Delta E}{E} = \frac{\frac{1}{2} v^2 \Delta m}{E} + \frac{mv\Delta v}{E}$$

$$\frac{\Delta E}{E} = \frac{\frac{1}{2} v^2 \Delta m}{\frac{1}{2} m v^2} + \frac{mv\Delta v}{\frac{1}{2} m v^2}$$

$$\frac{\Delta E}{E} = \frac{\Delta m}{m} + 2\frac{\Delta v}{v}$$

***Logarithmic method**

In some cases, multiplication or division, we can apply the logarithmic method which consists of

 take the logarithm of the quantity G, then its differential

 to take the absolute value of the expressions obtained

 and to replace the differentials by the absolute errors.

$$E = \frac{1}{2} m v^2$$

$$lnE = ln\left(\frac{1}{2} m v^2\right)$$

$$lnE = ln\frac{1}{2} + lnm + lnv^2$$

$$lnE = ln\frac{1}{2} + lnm + 2lnv$$

$$\frac{dE}{E} = 0 + \frac{dm}{m} + 2\frac{dv}{v}$$

$$\frac{\Delta E}{E} = \frac{\Delta m}{m} + 2\frac{\Delta v}{v}$$

ChapterII : GEOMETRIC OPTICS

Main objective:

The second chapter allows the student to master the fundamental laws of geometric optics and their applications to different optical systems.

Prerequisites:

To follow this chapter the student must master the following notions:

*The trigonometric equations,

* Solving first degree equations with one unknown,

* The notions of image in a mirror.

Specific objectives :

At the end of this course, each student should be able to:

* State the laws and principles of geometric optics.

* Trace the path of a light ray based on the laws and principles of geometric optics through: A dioptre; a mirror ; a system; a thin lens.

* Determine the position of the image knowing that of the object and vice versa through an optical system.

* Describe microscope, telescope and their uses.

1-Introduction

Optics is the branch of physics which deals with the study of behavior and properties of light. Light is an electromagnetic wave having transverse nature. Although light has dual nature; particle as well as wave, classical approach considers only wave nature. The wave nature is further simplified in geometric optics, where light is treated as a ray which travels in straight line. Ray optics model includes wave effects like diffraction, interference etc. Quantum optics deals with application of light considered as particles (called photons) to the optical systems. The phenomena of photoelectric effect, X-rays and lasers are explained in the quantum optics (particle nature of light).

2-Ray Optics (Geometric optics)

Geometrical optics describes the propagation of light in terms of rays. The assumptions of geometrical optics are:

• Light travels in straight-line paths.

• It bends, or split into part, at the interface between two different media.

• It follows curved paths in a medium where refractive index changes.

• It may be reflected, absorbed or transmitted.

3-The Speed of Light:

The speed of light is now known to great precision. In fact, the speed of light in a vacuum c is so important that it is accepted as one of the basic physical quantities and has the fixed value.

$$c=299\,792\,458 \text{ m/s} \approx 3.00\times10^{8} \text{ m/s},$$

where the approximate value of 3.00×10^{8} m/s is used whenever three-digit accuracy is sufficient. The speed of light through matter is less than it is in a vacuum, because light interacts with atoms in a material. The speed of light depends strongly on the type of material, since its interaction with different atoms, crystal lattices, and other substructures varies. We define the **index of refraction n** of a material to be

$$n = \frac{c}{v} > 1.$$

where**v** is the observed speed of light in the material. Since the speed of light is always less than c in matter and equals c only in a vacuum, the index of refraction is always greater than or equal to one.

Table .1 gives the indices of refraction for some representative substances.

Medium	n
Air	1.000277
Water, fresh	1.333
Glass, crown	1.52
Diamond	2.415
Glycerine	1.473
Carbondioxide	1.00045
Zircon	1.923

Example : Speed of Light in Matter

Calculate the speed of light in zircon, a material used in jewelry to imitate diamond.

Solution:

The equation for index of refraction states that$n = \frac{c}{v} \Rightarrow v = \frac{c}{n} = \frac{3*10^8}{1.923} = 1.59 * 10^8\ m/s.$

4-Reflection and refraction of light

4.1 Reflection of Light

Reflection is the bouncing back of light at an interface between two different media. Glassy surfaces such as mirrors exhibit specular reflection. This allows for production of reflected images that can be associated with real or virtual location in space. Figure 1 depicts the phenomenon of reflection from a glass-air interface. PO is the light ray incident on a glass mirror at an angle θ_i (angle of incident) and OQ is the light ray reflected from the surface at an angle θ_r (angle of reflection).

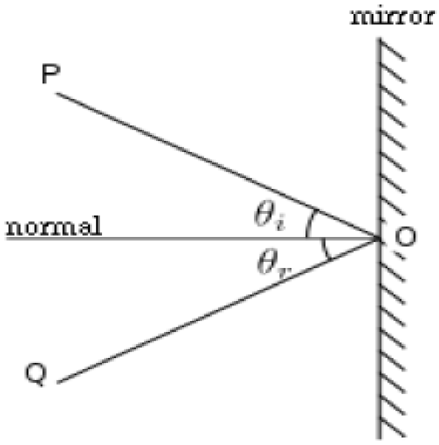


Fig. 1 Reflection of light[1]

4.2 Laws of reflection:

1) The incident and reflected ray and the normal, all lie in same plane, and

2) The angle between the incident ray and the normal is the same as that between the reflected ray and the normal i.e. $\theta i = \theta r$

4.3 Refraction of light

When a light ray passes from one transparent medium to another, it gets deviated from its original path while crossing the interface of two media. The phenomena of bending of light rays from their original path while passing from one medium to another is called refraction.

• When light travels from a rarer medium to denser medium, it bends towards the normal.

• When light travels from a denser medium to rarer medium, it bends away from the normal.

It happens when light travels through medium that has a changing index of refraction. Refraction occurs due to change in speed of light as it enters a different media. Figure.2 describe the occurrence of refraction at an interface.

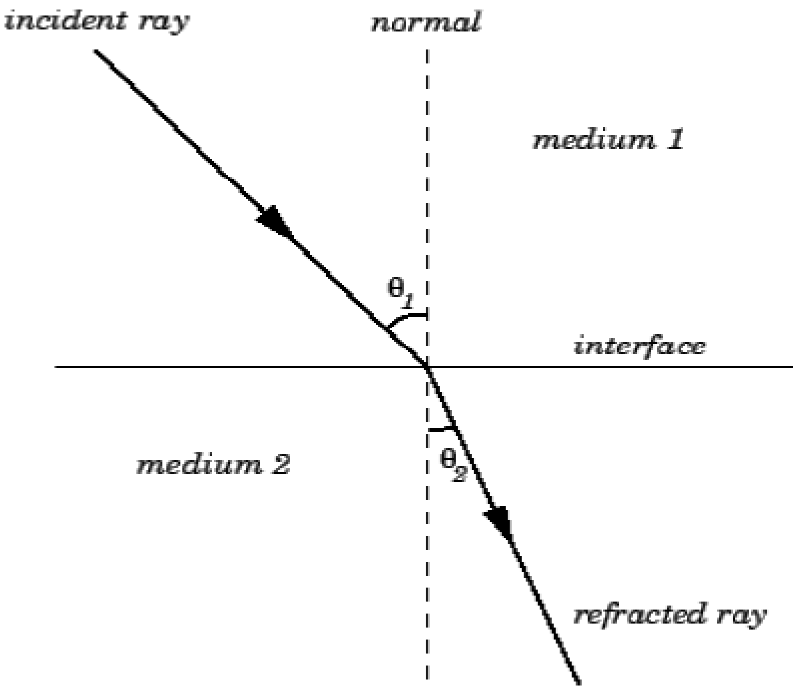


Fig.2 Refraction of light[1]

4.4 Laws of refraction:

1) The incident ray, the refracted ray and the normal all lie in the same plane.

2) The exact mathematical relationship is the law of refraction, or "Snell's Law," which is stated in equation form as

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

Example .2 : Determine the Index of Refraction from Refraction Data

Find the index of refraction for medium 2 in Figure 2, assuming medium 1 is air and given the incident angle is 30.0º and the angle of refraction is 22.0º .

Solution

Snell's law is $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$$n_2 = n_1 \frac{\sin \theta_1}{\sin \theta_2} = 1 * \frac{\sin 30}{\sin 22} = 1.33$$

5-Total Internal Reflection

A good-quality mirror may reflect more than 90% of the light that falls on it, absorbing the rest. But it would be useful to have a mirror that reflects all of the light that falls on it. Interestingly, we can produce total reflection using an aspect of refraction. Consider what happens when a ray of light strikes the surface between two materials, such as is shown in Figure 3(a). Part of the light crossesthe boundary and is refracted; the rest is reflected. If, as shown in the figure, the index of refraction for the second medium is less than for the first, the ray bends away from the perpendicular. (Since $n_1 > n_2$, the angle of refraction is greater than the angle of incidence—that is, $\theta_1 > \theta_2$.) Now imagine what happens as the incident angle is increased. This causes θ_2 to increase also. The largest the angle of refraction θ_2 can be is 90º , as shown in Figure 3(b).The critical angle θc for a combination of materials is defined to be the incident angle θ_1 that produces an angle of refraction of 90º . That is, θc is the incident angle for which $\theta_2 = 90º$. If the incident angle θ_1 is greater than the critical angle, as shown in Figure 3 (c), then all of the light is reflected back into medium 1, a condition called total internal reflection.

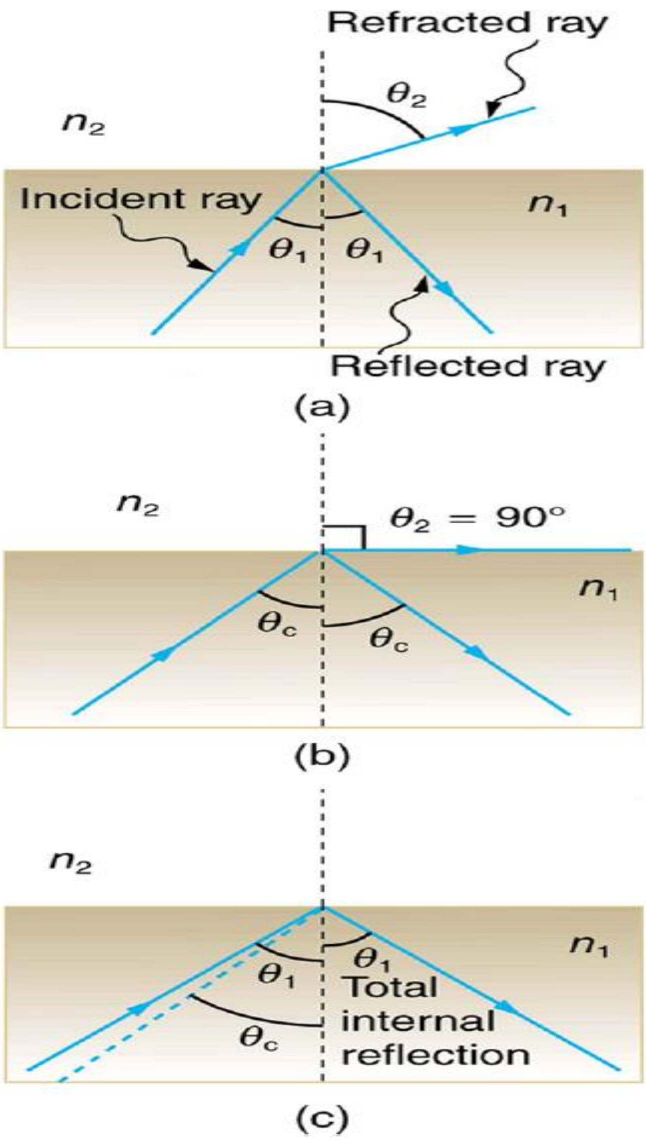


Figure 3 (a) [3]

A ray of light crosses a boundary where the speed of light increases and the index of refraction decreases. That is, $n_2<n_1$. The ray bends away from the perpendicular. (b) The critical angle θc is the one for which the angle of refraction is . (c) Total internal reflection occurs when the incident angle is greater than the critical angle.

Snell's law states the relationship between angles and indices of refraction. It is given by

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

When the incident angle equals the critical angle ($\theta_1 = \theta_c$), the angle of refraction is 90º (θ_2 = 90º). Noting that sin 90º=1 .The critical angle θ_c for a given combination of materials is thus

$$\theta_c = sin^{-1}\left(\frac{n_2}{n_1}\right)$$

6-Limit angle:

For θ_1 = 90°, a grazing incidence angle, the refracted ray forms, with the normal, the angle θ_2 such that :sini2=n1/n2.

$$\sin\theta_2 = \frac{n_1}{n_2}$$

$\theta_2$is thus called the limit angle θ_l .

$$\theta_l = sin^{-1}\left(\frac{n_1}{n_2}\right)$$

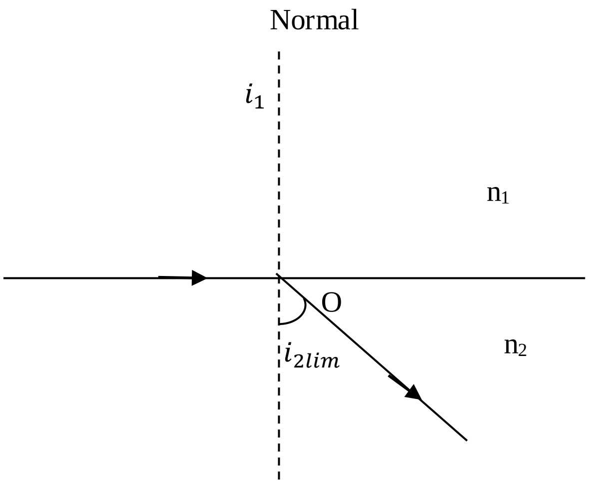


Fig. 4: angle limite de réfraction.

Example: How Big is the Critical Angle Here?

What is the critical angle for light traveling in a polystyrene (a type of plastic) pipe surrounded by air?

Solution

The critical angle is given by

$$\theta_c = sin^{-1}\left(\frac{n_2}{n_1}\right)$$

Substituting the identified values gives

$$\theta_c = sin^{-1}\left(\frac{1}{1.49}\right) = 42.2$$

7-Spherical mirrors

A spherical mirror is a concave or convex reflecting surface defined by the center of curvature C and a vertex S located on the surface. The curvature ray is $R = \overline{SC}$.

Fig. 5: example of spherical mirror [3]

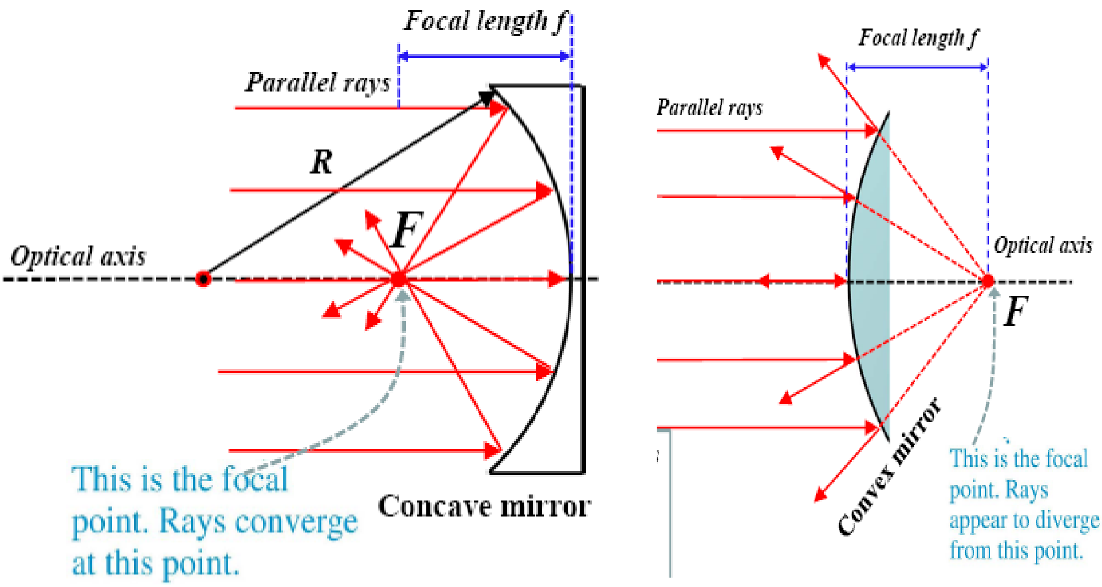


Fig. 6:types of spherical mirror

*The center **C** of is outside the mirror.

*Focal point **F** is also outside the mirror, half way between the center and the surface of the mirror.

* The focal length f is half of the radius.

Mirror Equation:

$\frac{1}{\overline{SA'}} + \frac{1}{\overline{SA}} = \frac{2}{\overline{SC}}$
(28)

Infinite distance, A(∞) → A′ ≡ F,image appears at ½ radius of curvature.

Nomenclature; focal length, f=R/2, is image length when object is at infinity.

Real image – formed by converging rays. Can be viewed on screen.

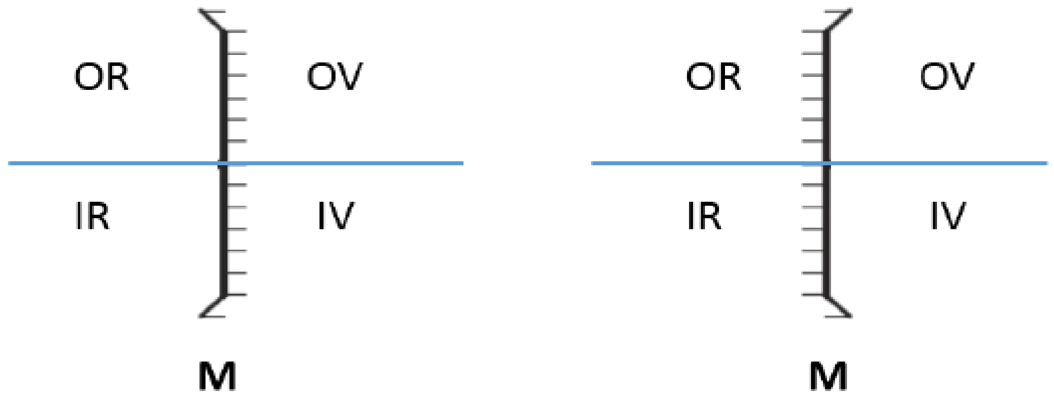
Virtual image – rays do not go through. Cannot be shown on screen.

Magnification:

If AB has an image of A'B', the magnification γ is the algebraic ratio of the size of the image to that of the object:

$$\gamma = \frac{\overline{A'B'}}{\overline{AB}} = -\frac{\overline{SA'}}{\overline{SA}}$$

$\overline{SA}$Object distance,$\overline{SA'}$Image distance



The images formed by convex mirror is always virtual, diminished, and erect and is formed behind the mirror. For concave mirror, the nature of image formed depends on the position of the object with respect to the mirror 'o' represents the object.

Application of concave mirror include its usage in reflecting telescopes, shaving mirrors, oculars, etc., while convex mirror are basically used as driving mirror due to their large field of view.

Formation of Images by Spherical Mirrors

In tracing ray diagram to obtain the image formed by spherical mirrors, four important rays are used, the intersection of any two of such rays, describes the nature and position of the image formed by the object. The rays are

i. All Paraxial rays are reflected from the mirror through the principal focus.

ii. All rays passing through the principal focus are reflected from the mirror parallel to the principal axis

iii. Ray of light passing through the center of curvature is reflected un-deviated from

the mirror.

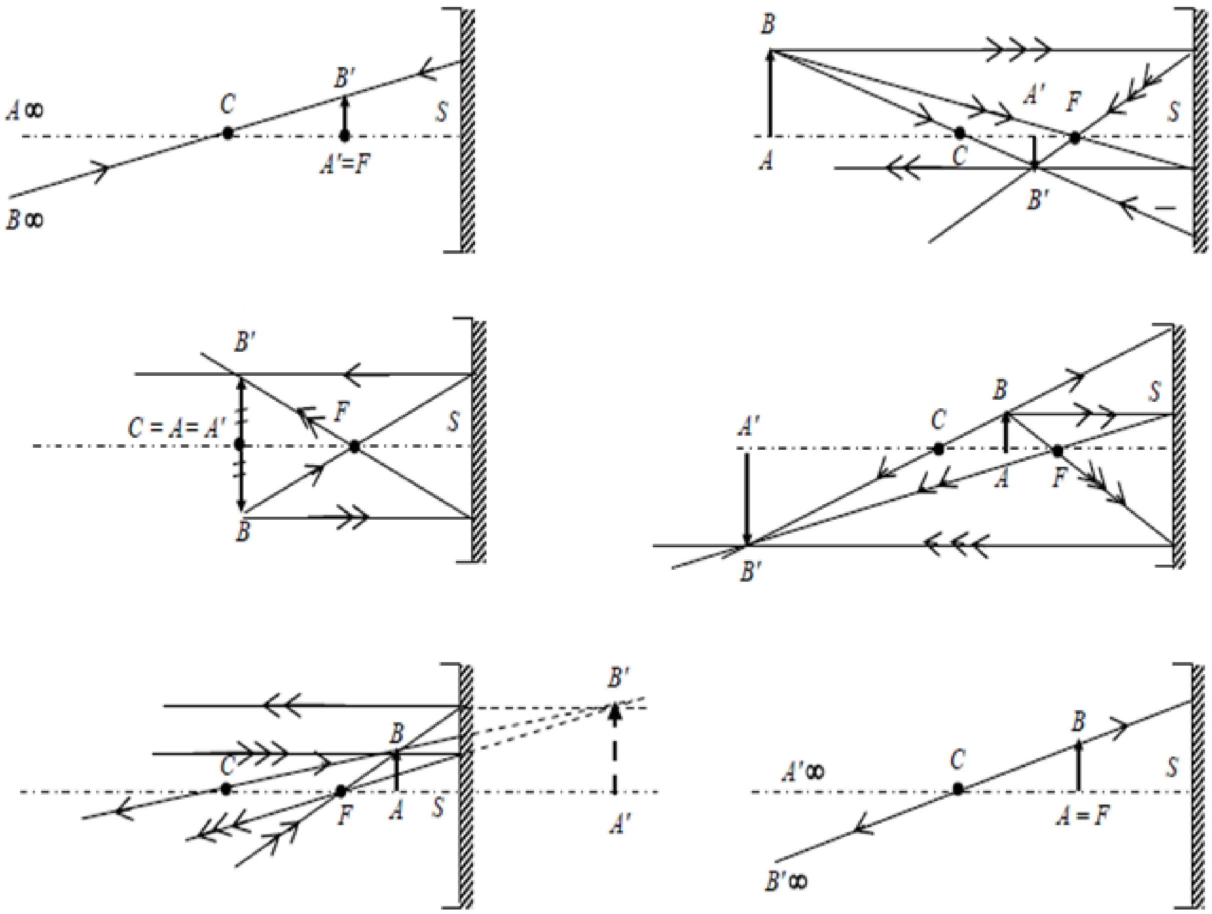


Fig.7 : Image formation by Spherical Mirrors[2]

Example:

1-A concave spherical mirror with a radius of curvature of 20 cm. With the two methods (graphics and calculation), determine the position, nature and size of the image of a 5 cm high object placed on the axis at: 30 cm from the top of the mirror.

2-Same work with a convex mirror

Solution :

1-concave sphericalmirror

$\overline{SA}$ = -30 cm $\Rightarrow \overline{SA'}$ = -15cm

$\gamma = \frac{\overline{A'B'}}{\overline{AB}} = - \frac{\overline{SA'}}{\overline{SA}} = = - \frac{-15}{-30}$ = -0.5 (le signe (-)invertedimage)

$\overline{A'B'} = 5 * 0.5 = 2.5\ cm$

2- convex mirror

$\overline{SA}$ = -30 cm $\Rightarrow \overline{SA'}$ = 7.5 cm

γ= $\frac{\overline{A'B'}}{\overline{AB}}$ = - $\frac{\overline{SA'}}{\overline{SA}}$ = = - $\frac{7.5}{-30}$ =0.25

$\overline{A'B'} = 5 * 0.25 = 1.25\ cm$

8- The spherical diopter:

Diopter is defined as the surface that separates 2 transparent media with different refractive index. This surface can be flat or curved. If it is a spherical surface, it is a spherical diopter.

a-The conjugation relationship :

$$\frac{n_2}{\overline{SA'}} - \frac{n_1}{\overline{SA}} = \frac{n_2 - n_1}{\overline{SC}} = V$$

$\overline{SA'}$image distance

$\overline{SA}$distance of object

$\overline{SC}$ = radius of curvature (> 0 when the cap has the convexity towards the object)

V = vertex of the cap (unit: Dioptrie = m^{-1}).

*If V >0 :convergent diopter

*If V <0 :divergent diopter

The image focus is the image of the point towards infinity on the axis :

$\frac{n_2}{\overline{SF'}} - \frac{n_1}{\infty} = \frac{n_2-n_1}{\overline{SC}} \rightarrow \overline{SF'} = f' = \frac{n_2}{n_2-n_1}\overline{SC}$ Ou $\overline{SC} = R$

F' is the image focus, $\overline{SF'} = f'$ is the image focal distance of the diopter.

The object focus is such that its image is to infinity on the axis :

$$\frac{n_2}{\overline{\infty}} - \frac{n_1}{SF} = \frac{n_2 - n_1}{\overline{SC}} \rightarrow \overline{SF} = f = -\frac{n_1}{n_2 - n_1}\overline{SC}$$

F is the object focus $\overline{SF} = f$ is the object focal distance of the diopter.

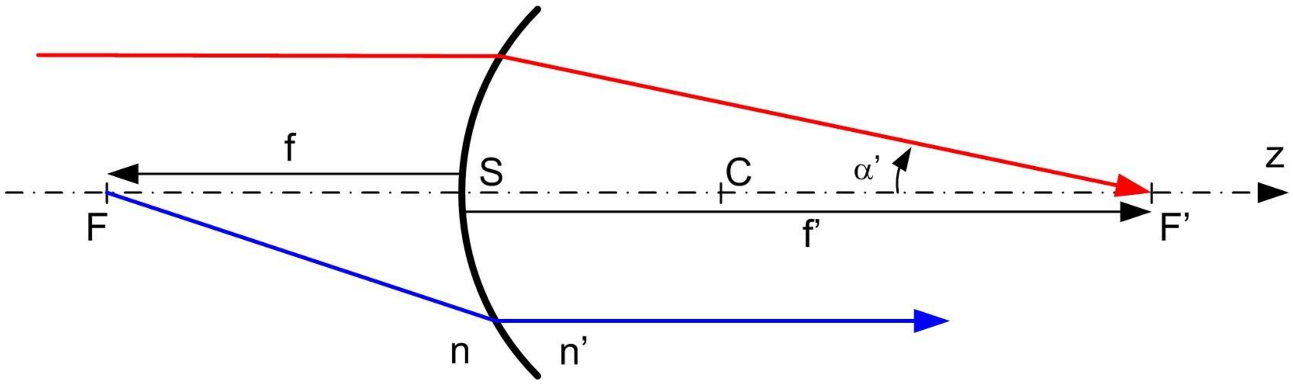


Fig.8 : the image focus and the object focus[3]

b-The transversal magnification relationship :

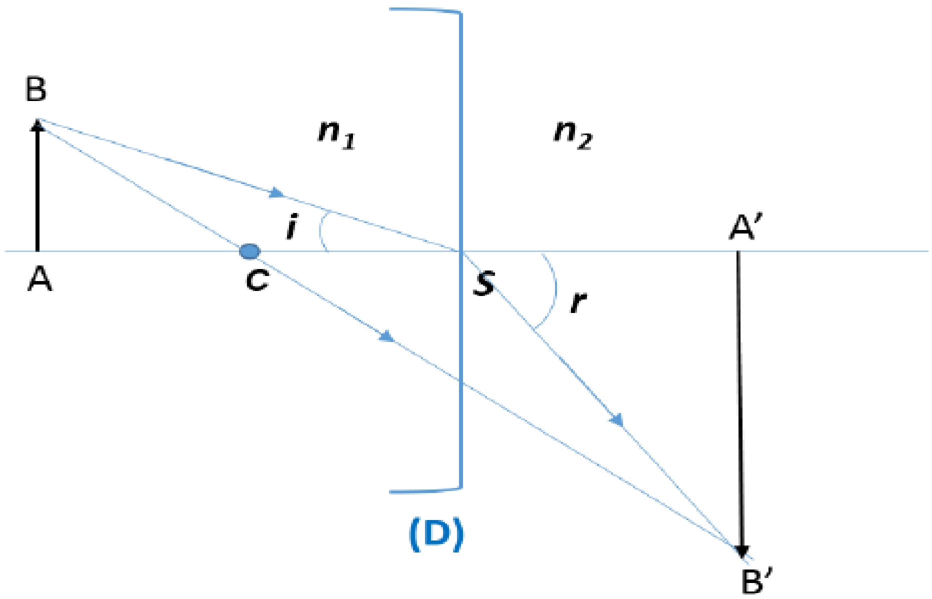


Fig.9 : Themagnification [3]

$$\gamma = \frac{\overline{A'B'}}{\overline{AB}} = \frac{n_1}{n_2}\frac{\overline{SA'}}{\overline{SA}}$$

c-Construction of the image of a point object:

To determine the image A' of an object A, at least two rays are needed.

There are three particular radii for spherical diopters:

• A light ray which passes through the center C of the interface is not deflected;

• A light ray which passes through the object focus F (or whose extension passes through F) emerges parallel to the optical axis;

• A light ray which arrives parallel to the optical axis of the interface emerges from the latter passing through its image focus F' (or seeming to come from F').

Convergent Diopter Divergent Diopter

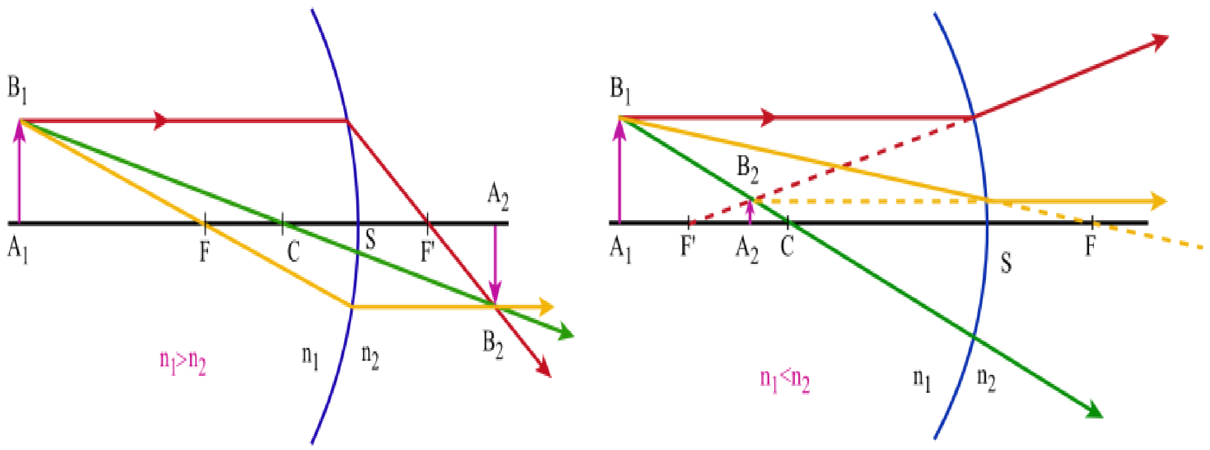


Fig.10 : Construction of the image [3]

Application:

A diopter has a radius of curvature of +200 mm and it separates air (n=1) from water (n=1.33). Calculate its power.

Solution :

$$V = \frac{n_{eau} - n_{air}}{\overline{SC}} = \frac{1.33 - 1}{0.2} = +1.65\ \delta$$

9. Lenses

Two spherical diopters facing and very close together form a thin lens, the thickness of which is negligible compared to the diameter and the radii of curvature of thespherical surfaces that surround it.They are made of transparent medium of index n between two diopters of radius $R_1$and R_2. The lens axis goes through the curvature centers of the sides. This axis cuts the diopters at their vertex S_1 and S_2. e = S_1S_2 is the thicken at the vertex of the lens.

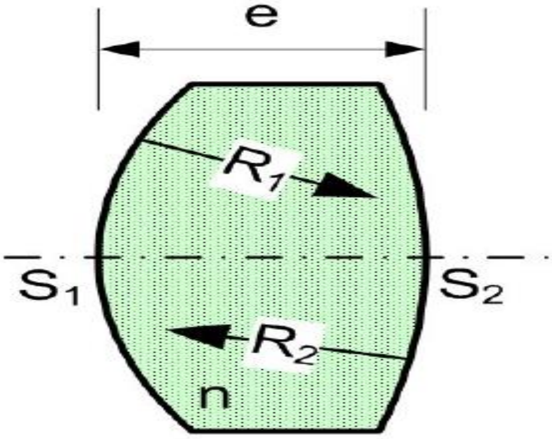


Fig.11 : the lens

There are two types of lenses: convergent and divergent (See Fig. 9.2). A convergentlens makes incoming parallel rays converge, or come together. A convergent lens typically has a convex surface and is thicker at the center than at the edge. The focal length of a convergent lens is positive. A divergent lens makes incoming parallel rays diverge, or spread apart. A divergent lens typically has a concave surface and is thinner at the center that at the edge. The focal length of a divergent lens is negative.

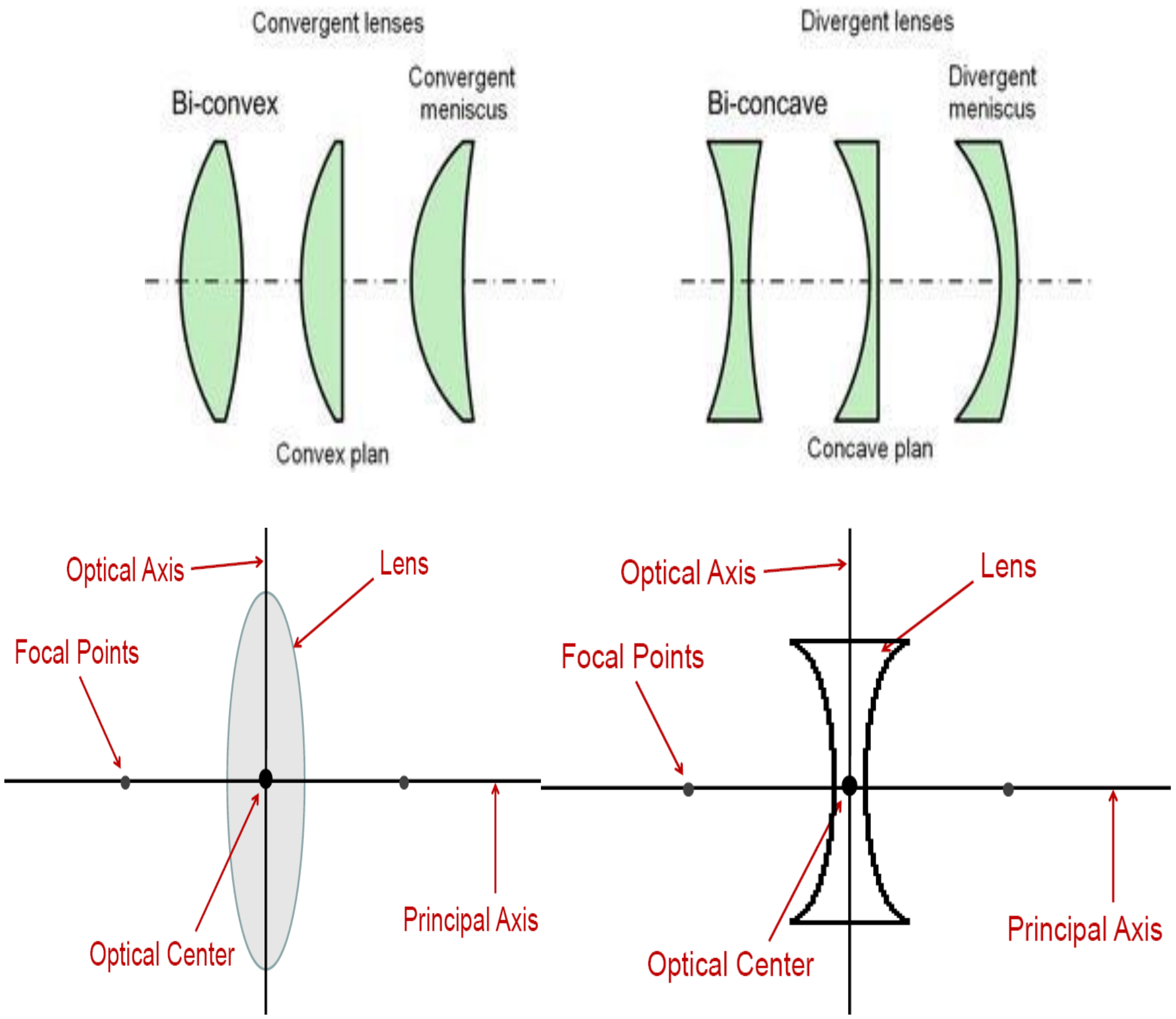


Fig.12 : Types of the lens[2]

a-Thin Lens Formula:

The focal length of a lens (f) is related to object distance ($\overline{SA}$) and the image distance ($\overline{SA'}$) by the Thin Lens Formula:

$$\frac{1}{\overline{SA'}} - \frac{1}{\overline{SA}} = \frac{1}{f'} = V$$

For thin lens of index n in the air: (n1 = 1): $\frac{1}{\overline{SA\prime}} - \frac{1}{\overline{SA}} = (n-1)[\ \frac{1}{\overline{S_1C}} + \frac{1}{\overline{SC_2}}] = V$

*If the object is very far from the lens, the object distance is considered to be infinity. In this case, the rays from the object are parallel, $1/\overline{SA}$ equals zero, and the image distance equals the focal length. This leads to the definition of the focal point as the place where a lens focuses incoming parallel rays from a distant object. A lens has two focal points, one on each side. The distance from the lens to each focal point is the focal length.

*The power of a lens V is measured in units called diopters. To calculate a lens's power in diopters, take the reciprocal of its focal length in meters.

b-Image Focus F' and Object Focus F:

The image focus F' is given by: $\overline{SF'} = f' = \frac{1}{V}$

The object focus F is given by: $\overline{SF} = f = -\frac{1}{V}$

F and F' are symmetric with respect to S.

For a converging lens, F and F' are real, while for a diverging lens, they are virtual.

***Converging lens:**

V >0 ; $\overline{SF'}$ > 0 ; $\overline{SF}$ < 0

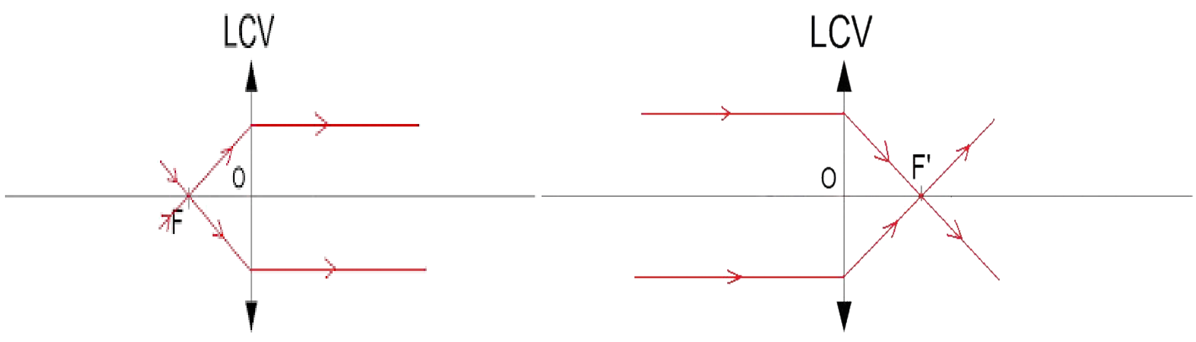


Fig.13: Image Focus F' and Object Focus F for a converging lens. [2]

***Diverging lens:**

V < 0 ; $\overline{SF'}$< 0 ; $\overline{SF}$>0

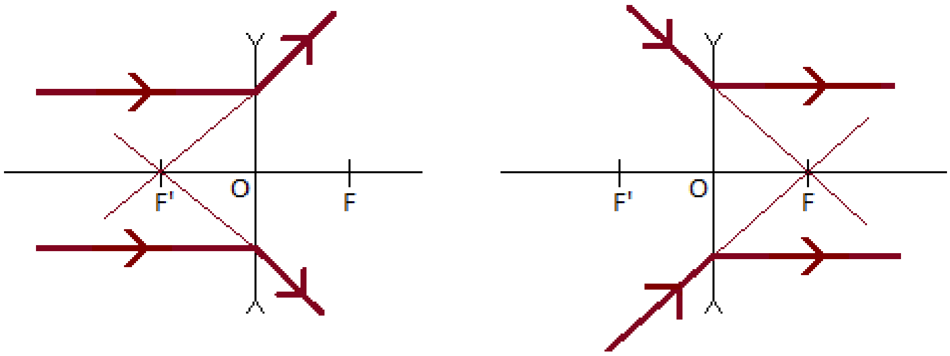


Fig.14: Image Focus F' and Object Focus F for a diverging lens. [2]

c-Magnification:

The size of an image can be different from the size of the object. The magnification, ,of the image is defined by

$$\gamma = \frac{\overline{SA'}}{\overline{SA}} = -\frac{\overline{SA'}}{\overline{SA}}$$

*If γ is greater than 1, the image is larger than the object; if γ is less than 1, the image is smaller. The magnification, γ, which can be positive or negative, represents both the size and orientation of the image. It can be defined in terms of the image and object distances.

*If γ is positive, the image is upright, or in the same orientation as the object. If γ is negative, the image is inverted, or in the opposite orientation to the object. If the object is right-side-up, then the inverted image appears upside-down.

d-Geometric construction:

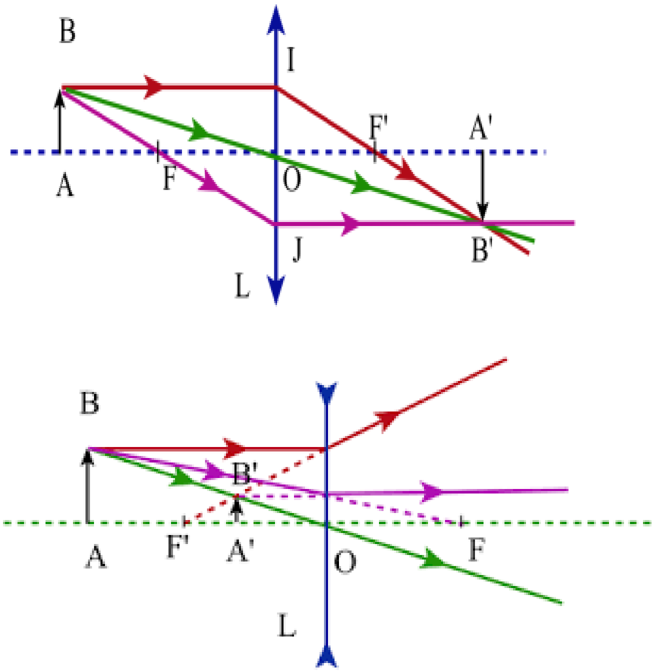


Fig.15: Geometric construction: [2]

10-The human eye and vision:

The human eye achieves vision by forming an image that stimulates nerve endings, creating the sensation of sight. Like a camera, the eye consists of an aperture and lens system at the front, and a light-sensitive surface at the back. Light enters the eye through the aperture- lens system, and is focused on the back wall.

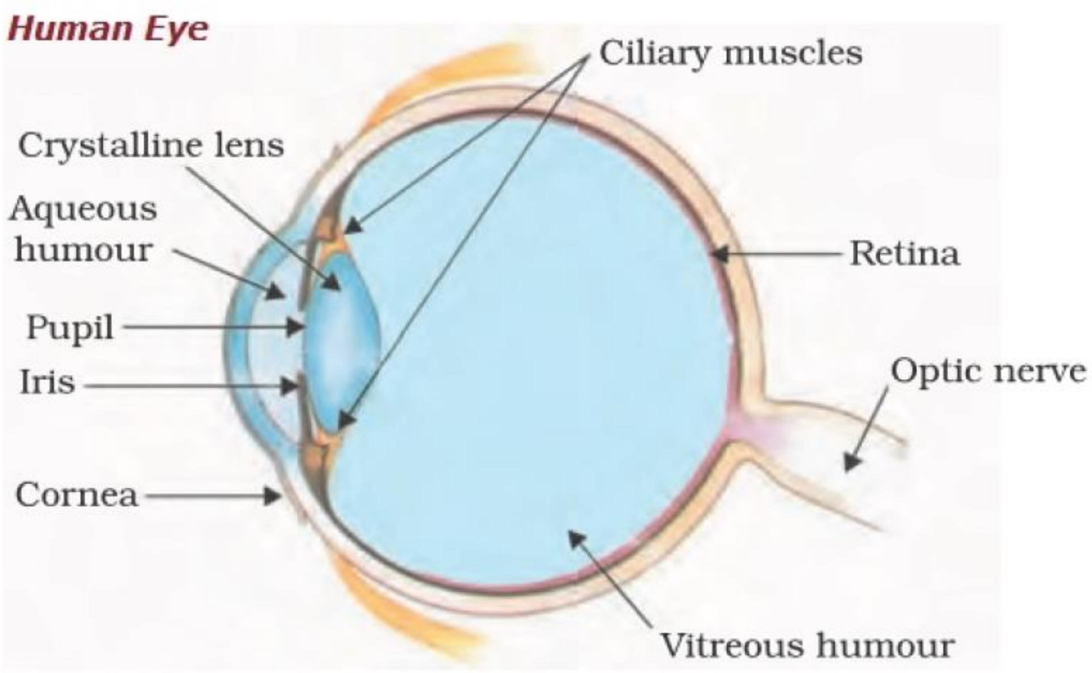


Fig.16:Horizontal cross section of the human eye. [2]

The lens system consists of two lenses: **the corneal lens** on the front surface of the eye, and the **crystalline** lens inside the eye. The space between the lenses is filled with a transparent fluid called **the aqueous humor**. Also between the lenses is **the iris**, an opaque, colored membrane. At the center of the iris is **the pupil**, a muscle-controlled, variable- diameter hole, or aperture, which controls the amount of light that enters the eye. The interior of the eye behind the crystalline lens is filled with a colorless, transparent material called **the vitreous humor**.

On the back wall of the eye is the retina, a membrane containing light-sensitive nerve cells known as rods and cones. Rods are very sensitive to low light levels, but provide us only with low-resolution, black-and-white vision. Cones allow us to see in color at higher resolution, but they require higher light levels. **The fovea**, a small area near the center of the retina, contains only cones

and is responsible for the most acute vision. Signals from the rods and cones are carried by nerve fibers to **the optic nerve**, which leads to the brain.

The optic nerve connects to the back of the eye; there are no light-sensitive cells at the point where it attaches, resulting in a **blind spot**.

a-Optics of the Eye

The corneal lens and crystalline lens together act like a single, convergent lens. Light entering the eye from an object passes through this lens system and forms an inverted, real image on the retina

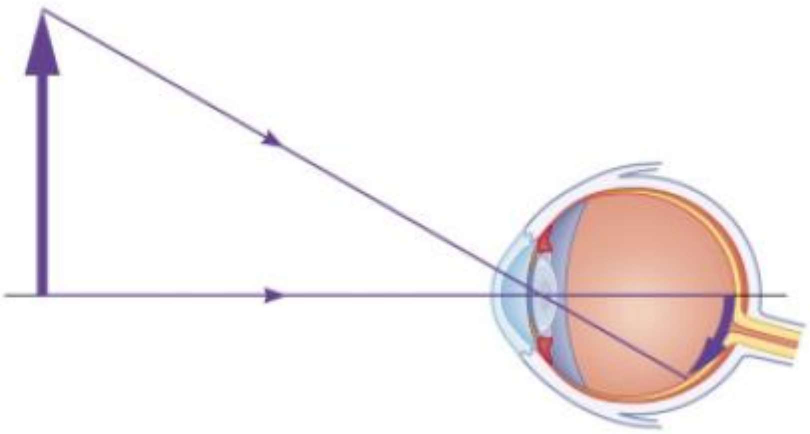


Fig.17:Image production in the eye[2]

The eye focuses on objects at varying distances by **accommodation**, or the use of muscles to change the curvature, and thus the focal length, of the crystalline lens. In its most relaxed state, the crystalline lens has a long focal length, and the eye can focus the image of a distant object on the retina. The farthest distance at which the eye can accommodate is called the far point for distinct vision. **For a normal eye, the far point is infinity**.

When muscles in the eye contract and squeeze the lens, the center of the lens bulges, causing the focal length to shorten, and allowing the eye to focus on closer objects. The nearest distance at which they eye can accommodate is called the near point for distinct vision. **The near point of a normal eye is about 25cm.**

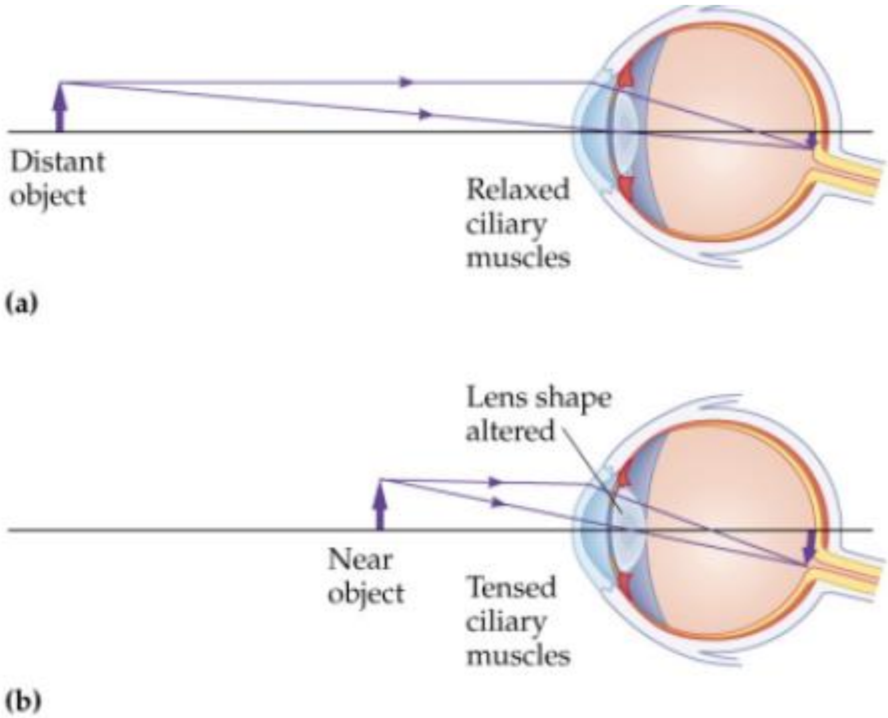


Fig.18:Accommodation in the human eye[2]

(a) When the eye is viewing a distant object the ciliary muscles are relaxed and the focal length of the lens is at its greatest. (b) When the eye is focusing on a near object the ciliary muscles are tensed, changing the shape and reducing the focal length of the lens.

b-Visual Defects and their Correction:

A normal eye can focus by accommodation on any object more than about 25cm away. In cases where an eye cannot focus on an object, the image is formed either behind or in front of the retina, resulting in blurred vision. This can be caused by the eye being too short or too long.

***Near-Sightedness (Myopia):**

A person affected by myopia has an eye ball that is too long, making the distance from the lens system to the retina too large. This causes the image of distant objects to be formed in front of the retina. The far point of a myopic eye is less than infinity.

A myopic eye can naturally focus divergent rays from a near object on the retina, but not parallel (or nearly parallel) rays from a distant object. Eyeglasses that correct myopia have a divergent lens, which forms a virtual image of the distant object closer to the eye.

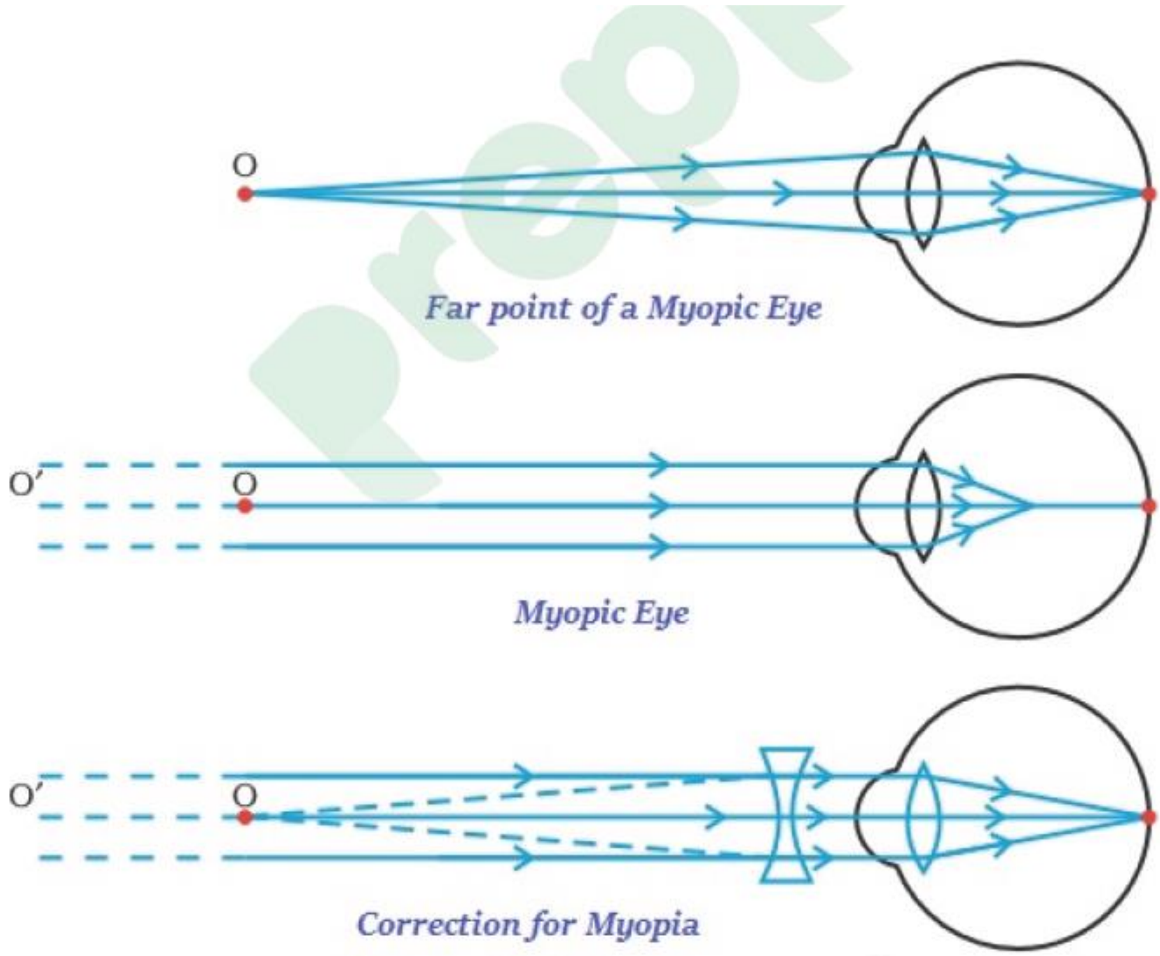


Fig.19: Myopia[2]

***Far-Sightedness (Hypermetropia):**

A person affected by hypermetropia has an eye ball that is too short, making the distance from the lens system to the retina too small. This causes the image of near objects to be formed behind the retina. The near point of a hypermetropic eye is greater than normal.

A hypermetropic eye can naturally focus parallel (or nearly parallel) rays from a distantobject on the retina, but not highly divergent rays from a near object. Hypermetropia can be corrected using eyeglasses that have a convergent lens, which reduces the divergence of incoming rays

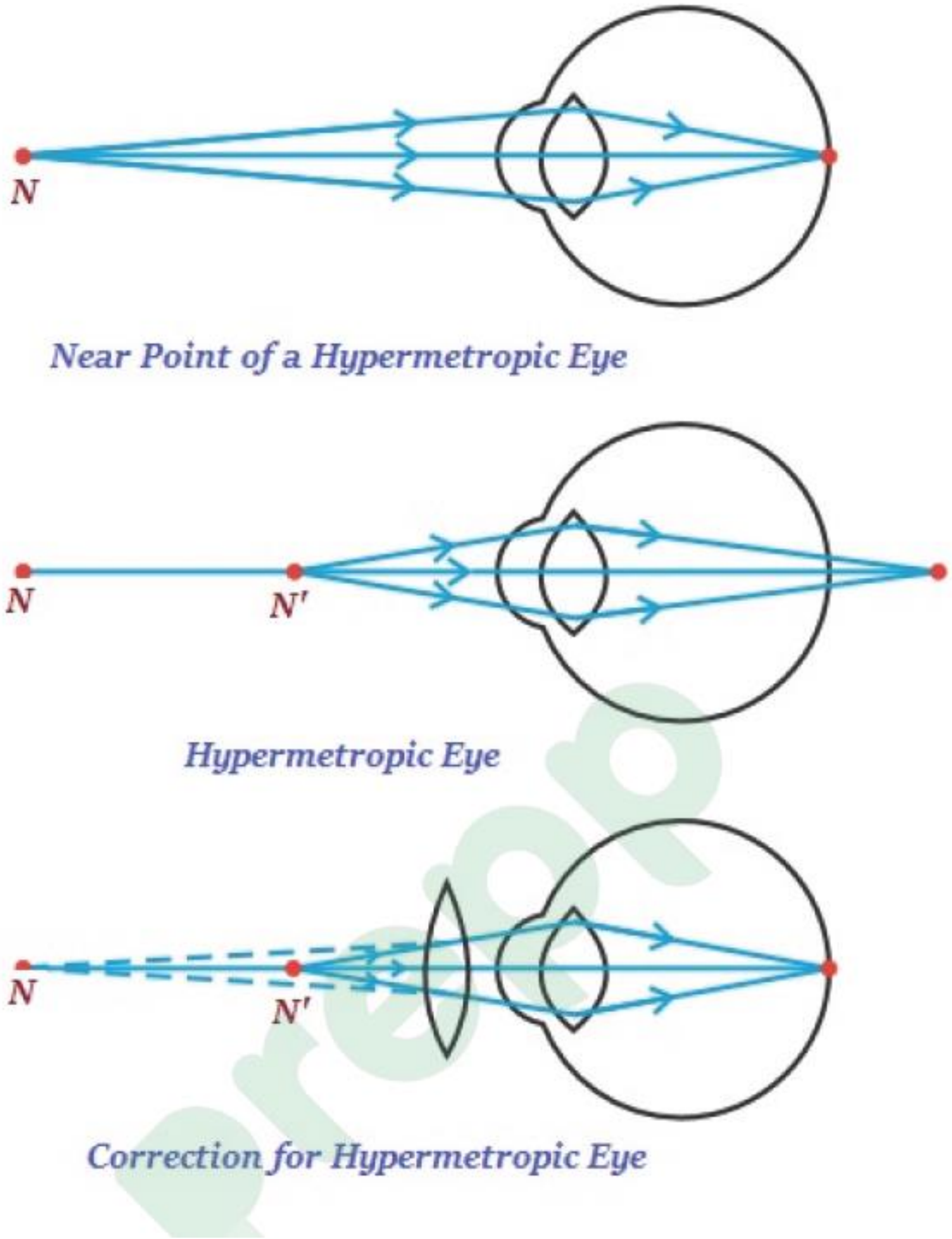


Fig.20: Hypermetropia[2]

ChapterIII : Fluid Mechanics

- **LEARNING OUTCOME**
- Describe the basic properties of fluids, quote applicable units and determine how these properties inter-relate to one another in fluid applications.
- State the basic principles of fluid statics and use these principles to determine static fluid pressure and forces.
- Use the Continuity Equation and the Bernoulli Equation to determine the changes that will occur when fluids flow through pipes or ducts of varying section or elevation.

OBJECTIVES

At the end of your study of this Section, you will be able to:

* describe the basic properties of fluids and units

* calculate one property given another (eg calculate mass given dimensions and relative density)

*state Pascal’s Law and Archimedes’ Principle

* calculate the pressure at any depth in a liquid

*describe the difference between steady and unsteady flow

* explain the meaning of the various terms in the Bernoulli Equation and sketch or graph theirvariation for ideal or real flow of a fluid through a tapered or inclined pipe or duct

Hydrostatic

1. Fluid Definitions

Matter can exist in three basic forms, either as a solid, a liquid or a gas

Solids retain their shape and have no tendency to flow

Liquids offer considerable resistance to compression, which is not greatly affected by changes in temperature.

Gases are easily compressed and have a change in volume (or pressure) when their temperature is changed.

Liquids and gases flow readily and collectively are known as fluids

a.liquids and gases:

The liquids and gases usually studied are isotropic, mobile and viscous. The physical property that differentiates between the two is compressibility.

• Compressible fluids: gases, which occupy all the space available to them (expandable fluid $\Rightarrow \rho$ varies according to the variation in volume)

• Incompressible or quasi-incompressible fluids: liquids, which occupy a given volume (unexpansive fluid or isovolume$\Rightarrow \rho$=cte)$\Rightarrow$ compressibility translates the decrease in volume in response to an increase in pressure.

b. Mass Density:

The mass density of a fluid (previously called the density) is its mass per unit volume, normally stated in kilograms per cubic metre (kg/m^3).

$$\rho = \frac{m}{V}$$

Typical mass densities are:

Material	Mass density(kg/m^3)
Water	**1000**
Sea water	**1024**
Mercury	**13600**
Oil	**800-900**
Air	**1.23**

c.RelativeDensity

The relative density of a fluid (previously called specific gravity) is the mass density of the fluid compared to the mass density of water.

$$d = \frac{\rho}{\rho_{H2O}}$$

For most normal calculations, the 1000 kg/m3 value stated above for the mass density of water is used to determine the relative density of a fluid. Because it is a ratio, relative density has no units.

For example,

relative density of water = 1

relative density of mercury = 13.6

relative density of oil = 0.89

d.Example :

Calculate the density of a petanque ball (m=710 g, Diameter= 7cm)

ρ_{H2O}= 1000 kg/m3 et $V_{boule} = 4/3.\pi.R^3$

Solution :

$V_{boule} = 4/3.\pi.R^3 = 4/3.\ \pi.(7*10^{-2})^3 = 1.43*10^{-3}\ m^3$

$$d = \frac{\rho}{\rho_{H2O}} = \frac{m}{V\rho_{H2O}} = \frac{7.10^{-3}}{1000.1.43.10^{-3}} = 5.10^{-3}$$

e- Weight Density:

The weight density (originally known as the specific weight) of a fluid is its weight per unit volume, with units of newtons per cubic metre. The weight density is calculated by multiplying the mass density by 9.8, the value for the gravitational acceleration.

weight density (N/m3) = mass density (kg/m3) x g (m/s2)

f-Example :

If a 25 litre volume of oil has a mass of 20 kilograms, determine the oil's mass density, weight density, relative density

Solution :

$$\rho = \frac{\mathrm{m}}{\mathrm{V}} = \frac{20}{0.025} = 800kg/m^3$$

$$\text{Weight Density} = \rho * \mathrm{g} = 800 * 9.8 = 7840\ \mathrm{N}/m^3$$

$$\mathrm{d} = \frac{\rho}{1000} = \frac{800}{1000} = 0.8$$

Viscosity: characterizes the ability of a fluid to flow

Perfect fluid: ideal case where it is considered that there is no friction between the molecules; the movement of the fluid takes place "as one block", the energy is conserved: no viscosity

Real fluid: molecules interact with each other during flow: internal friction sources of energy loss; if part of the fluid is set in motion, this movement is communicated step by step to the neighboring regions, but gradually weakening (speed gradient). Each layer "resists" the driving movement: viscosity

2.Pressure

As shown in Figure 1, pressure occurs when a force is applied to an area.

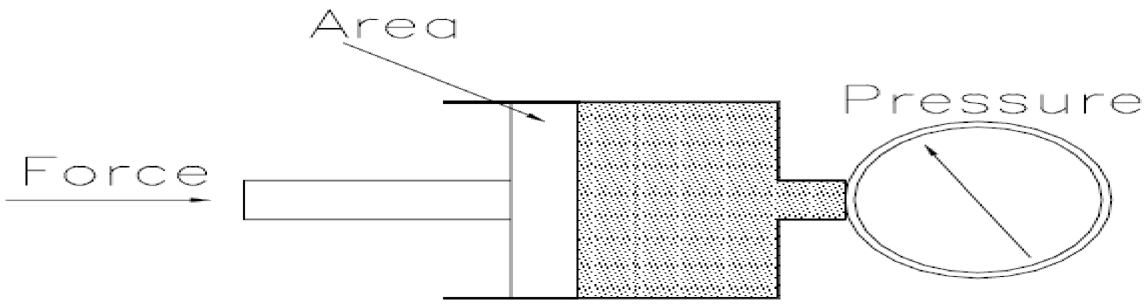


Fig. 1. Force producing a pressure [8]

The relationship between force, pressure and area is:

$$P = \frac{\vec{F}}{A}$$

• **P** :pressurein Pascal (Pa)

• **F** : force in Newton (N)

• **A**:area in (m^2)

Example :

1-Write what 1 [Pa] is in terms of units of force and area.

2- A 50.0 [kg] object is placed on the ground. Its horizontal section is 0.250 [m^2].

How much pressure does his weight exert on the ground?

Solution :

1/   1[Pa] = 1 [$\frac{N}{m^2}$]

2/

$$P = \frac{F}{A} = \frac{m.g}{A} = \frac{50.9.81}{0.250} = 1962\ Pa$$

3.Positive and Negative Pressures

Because we are subjected to an atmospheric pressure, the pressure indicated on a gauge can be either positive (pressure) or negative (vacuum).

Above atmospheric pressure is positive and called a gauge pressure for clarity. A typical pressure gauge would be calibrated in kPa. Below atmospheric pressure is negative and called a vacuum or a negative pressure. Figure .2 indicates the relationship between the pressure and vacuum ranges, and introduces the concept of one pressure range starting from absolute zero pressure and called the absolute pressure range.

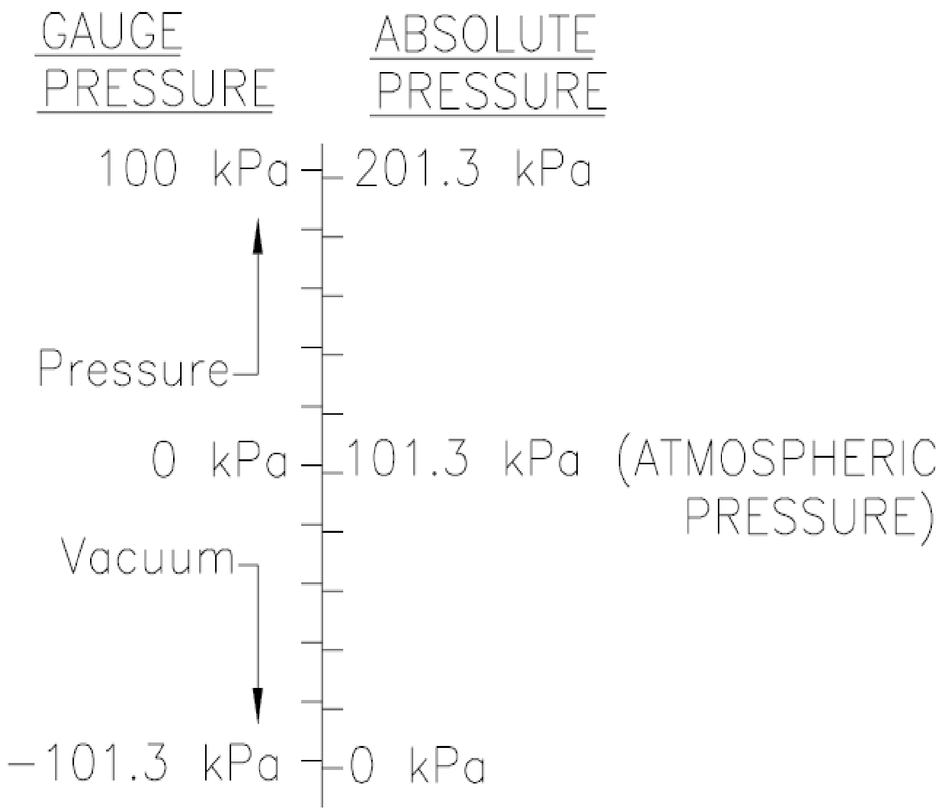


Fig. 2 Pressure/vacuum relationships [8]

Understanding of these pressure ranges is important. We normally express pressures in terms of gauge pressure, and before these values may be used in calculations regarding the change of state of a gas, the gauge pressure must be changed into an absolute pressure. Changing to absolute values is done by adding the accepted value for atmospheric pressure, nominally 101.3 kPa.

absolute pressure (kPa) = gauge pressure (kPa) + 101.3 kPa

4.Pascal's Law :

Pascal's Law states that, when a pressure is applied to a contained fluid, the pressure is transmitted throughout the fluid without loss. This simple principle can be illustrated with a braking system on a car - when a force is applied to the hydraulic fluid the force is converted to a pressure that is transmitted throughout the vehicle, and applied to all brakes equally. The actual output force at the brakes depends on the size of the slave cylinder, but an equal pressure is available to provide the output force.

Pascal's Law is a statement of one of the principles of fluid mechanics, with particular reference to what happens when a fluid is static, as opposed to dynamic. In other words, we are only considering static pressures and forces, not moving forces.

Other important principles for a static fluid are:

The pressure at any point in a fluid is the same in all directions.

At this point, although we are considering fluids generally, we will tend to consider liquids because,although the principles apply to a gas, the variations in pressure in a gas due to elevation/depth are negligible due to its low mass density.
Pressure in a static liquid depends on its mass density (ρ) and the vertical distance (h) from the point considered to the surface of the liquid.
This may be restated as:
pressure = mass density x gravitational acceleration x height
or, in symbol format:

$$\Delta P = P_B - P_A = \rho g h$$

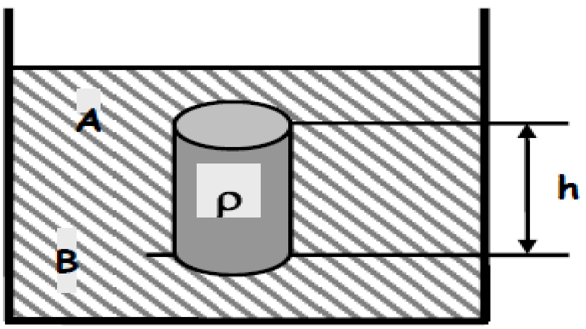


Fig.3 Pressure as a function of depth. [8]

Example: A reservoir supplies fresh water through a pipe to a town 83 metres below the reservoir. Calculate the pressure in the town (assuming the water is static)

Solution:

$\Delta P = \rho gh = 1000*9.81*83 = 813$ KPa

Note that the above pressure is a gauge pressure, because it is the calculated pressure above atmospheric pressure.

5.Measuring devices:

Manometers in the general case.

Barometers for measuring atmospheric pressure.

a – The Torricelli barometer (or mercury barometer, 1643)

In the mercury column we have: $P_1 - P_0 = \rho gh$

But $P_0 = 0$, and according to the principle of hydrostatics

$P_1 = Patm \Longrightarrow Patm = \rho_{Hg} gh$ and $h = \frac{\text{Patm}}{\rho_{Hg} g}$

Since $\rho_{Hg} \sim 13600\ kg/m^3$, the normal atmospheric pressure (1 atm =1.013 105 Pa) corresponds to a column height of mercury $h = \frac{1{,}013.10^5}{13600*9.81} = 0.76m = 760\ mm$

The pressure of 1 atm therefore corresponds to 760 mm Hg

 Note 1: Torr is often used in medicine, which corresponds to 1mm Hg.

 Note 2: If we replaced the column of mercury with a column of water (density ρ_{H2O} = 1000 kg/m^3), it would have a height $h = \frac{1{,}013.10^5}{1000*9.81} = 10\ m$

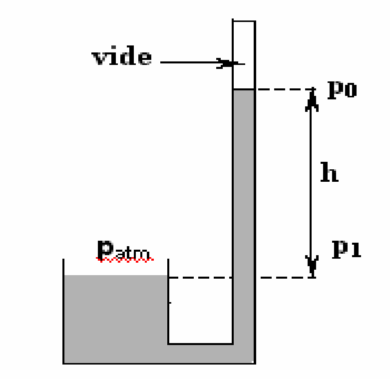


Fig.4: Torricelli's barometer. [8]

b – The liquid manometer

vertical U-Tubecontaining a liquid of known density ρ (water, oil, or mercury for high pressures). Measurement of the pressure p of a gas or another liquid (immiscible with that of the tube). The opening A of the tube is at the pressure Patm, the other at the pressure P

This involves expressing P as a function of h:

Inside the liquid, point B is at pressure p.

$P_B - P_A = \rho g h \Rightarrow P = P_{atm} + \rho g h$

The quantity ρgh is called the gauge pressure .

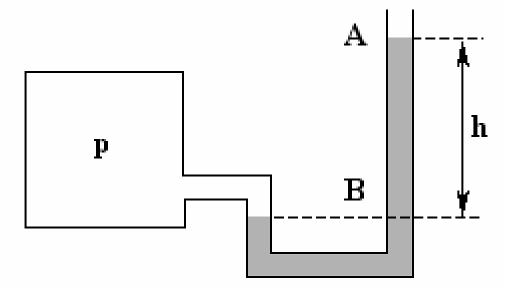


Fig.5: The liquid manometer. [8]

6. Applications

a. Communicating vessels:

The height of water (ρ=ct in both containers) must be the same in each of the containers

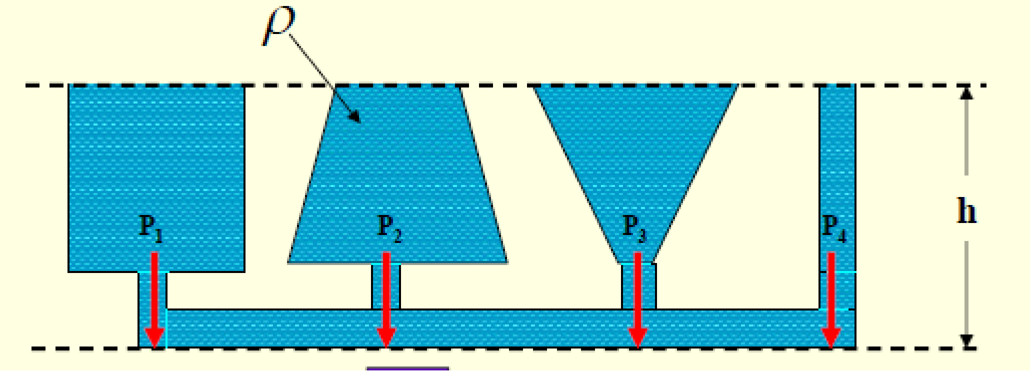


Fig.6: Communicating vessels. [8]

The pressure in a fluid depends only on the depth and not on the shape of the container. $P_1=P_2=P_3=P_4$

b. Thehydrauliccylinder:

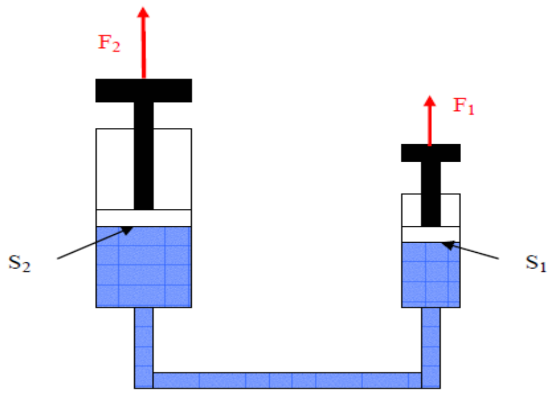


Fig.7hydraulic cylinder. [8]

The hydraulic cylinder is an extremely used tool. It allows a large force to be exerted by exerting a smaller force. Two syringes are connected by a flexible tube filled with liquid and a push is exerted on both sides. We realize that the force felt on piston n°2 (the big one) is greater than on piston n°1 (the small one). This difference is due to the difference of the surfaces A_1 and A_2.

The pressure in the pipe is the same in each place. So, from the relation P=F/S , we can write $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ soit $\frac{A_2}{A_1} = \frac{F_2}{F_1}$

The more the ratio of the surfaces is in favor of the piston n°2, the more the force F_2 is high compared to F_1 multiplying forces, is it magic? In reality, this is not magic. Admittedly, the force exerted on piston n°2 is greater than that exerted on piston n°1, but the displacements of the pistons are in the opposite direction: the small piston must move much more than the large piston. (seefig8)

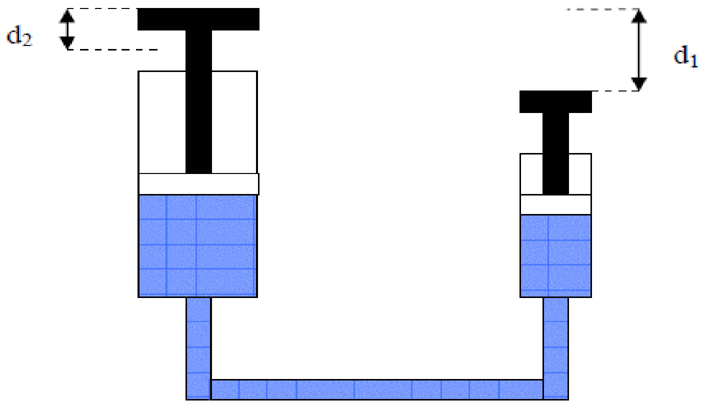


Fig.8:Principe du vérin hydraulique. [8]

If piston no. 2 is pressed, the displacement distance d_1 is greater than the displacement distance d_2.

7. Archimedes thrust:

A solid placed in a liquid at rest can assume one of the following positions:

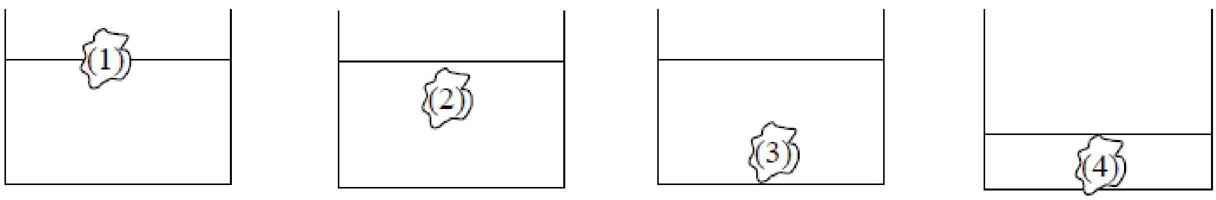


Fig.9:The positions of a solid placed in a liquid at rest [8]

1) Only part of the solid is immersed (inside the liquid) We say that "the solid floats"

2) The solid is completely immersed and remains between 2 liquid layers

3) The solid is completely submerged but touches the bottom (it sinks)

4) There is little liquid to conclude.

In the different cases, the solid undergoes from the liquid that surrounds it a vertical thrust (Archimedean thrust), directed from bottom to top and equal to the weight of the volume of the displaced liquid. This force is applied to the center of gravity of the displaced liquid.

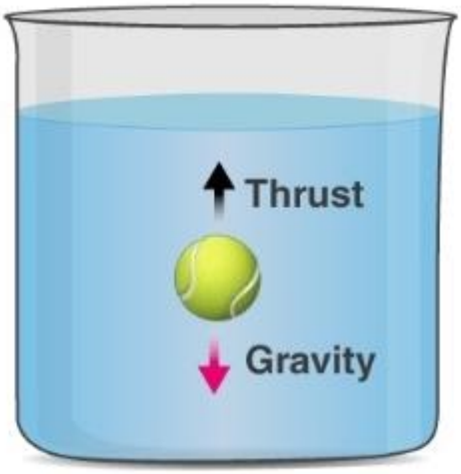


Fig.10:Principle of Archimedes thrust. [7]

Archimedes' principle states that:

The principle established by Archimedes states that an object submerged in a fluid, either partially or completely, experiences an upward buoyant force. This force is equivalent to the weight of the displaced fluid and acts in an upward direction through the center of mass of the displaced liquid. Observing figure 10, we note that the gravitational force acting on the object is countered by the buoyant force exerted by the fluid. Consequently, the object within the liquid perceives a net force equivalent to its apparent weight. Due to the fluid's upthrust reducing the effect of gravity, the object appears lighter than its actual weight in air. The apparent weight can be expressed as:

Apparent weight = Weight of the object (in air) - Buoyant force

Thus, Archimedes' principle demonstrates that the reduction in weight corresponds exactly to the weight of the displaced fluid.

Archimedes' Principle Formula

In its simplest form, Archimedes' principle states that the buoyant force exerted on an object is equal to the weight of the displaced fluid. Mathematically, this is expressed as:

$$F_b = \rho \times g \times V$$

Where Fb represents the buoyant force, ρ denotes the fluid's density, V is the volume of the submerged portion, and g corresponds to gravitational acceleration. The thrust force, also referred to as the buoyant force, plays a crucial role in enabling objects to float. Hence, this equation is alternatively known as the law of buoyancy.

Fb (N), ρ (Kg/m³), g (m/s²), V (m³)

Applications of Archimedes' Principle

1. Submarine:

Submarines remain submerged due to a specialized component known as the ballast tank. This tank allows water to enter, increasing the submarine's weight until it surpasses the buoyant force, ensuring it remains underwater.

2. Hot-Air Balloon:

Hot-air balloons ascend and float because their buoyant force is lower than the surrounding air. By adjusting the amount of hot air inside the balloon, the buoyant force changes, causing it to rise or descend accordingly.

3. Hydrometer:

A hydrometer is a device used to measure the relative density of liquids. It contains lead shots at its base, enabling it to float upright. The depth to which the hydrometer sinks depends on the liquid's density; lower density results in deeper submersion.

Example :

Problem Statement:

1. Determine the net force acting on a steel sphere with a radius of 6 cm when fully immersed in water.

2. Compute the buoyant force on a floating body that is 95% submerged in water. Assume the density of water is 1000 kg/m³.

Solution:

1. Calculation for the Steel Sphere:

- Given radius of the sphere: $r = 6$ cm $= 0.06$ m

- Volume of the sphere is calculated using the formula:

$V = (4/3) * \pi * r^3$

$= (4/3) * \pi * (0.06)^3$

$\approx 9.05 \times 10^{-4}$ m³

- Using Archimedes' principle:

$F_b = \rho \times g \times V$

$= 1000 \times 9.81 \times 9.05 \times 10^{-4}$

≈ 8.87 N

2. Calculation for the Floating Body:

- According to Archimedes' principle:

$F_b = \rho \times g \times V$

- For a floating body:

$V_b \times \rho_b \times g = V \times \rho \times g$

where:

- ρ and V represent the density and volume of the displaced water.
- ρ_b and Vb represent the density and volume of the floating body.
- Rearranging the equation to find ρb:

$\rho_b = \rho \times (V / Vb)$

Since the body is 95% submerged:

$0.95\ V_b = V$

Thus:

$\rho_b = 1000 \times (0.95\ V_b / V_b)$

$= 950\ kg/m^3$

Hydrodynamique:

Fluid Flow

The fundamental unit for quantifying a fluid's volumetric flow rate is cubic meters per second (m^3/s). In industrial settings, this is often abbreviated as ‘cumecs.’ Additionally, volume flow rates may be represented in liters per second (L/s) since cubic meters per second is a relatively large unit, typically used in contexts such as river flows or large pipeline systems. The mathematical relationship linking velocity to volume flow rate is given by:

Flow (m^3/s) = velocity (m/s) x cross-sectional area (m^2)

$$Q = A.v$$

Occasionally, the mass flow rate is required to be known. For instance, steam flow from a boiler israted in kilograms per second. To determine the mass flow rate, the mass density of the fluid is incorporated:

Mass flow rate (kg/s) = velocity (m/s) x area (m^2) x mass density (kg/m^3)

Example

Calculate the volume flow in a pipe that is 35 mm diameter and carries hydraulic oil at 3 m/s. Then calculate the mass flow, if the oil has a relative density of 0.8.

Solution:

$$Q = A.v = 3 * \pi * R^2 = 3 * \pi * \frac{0.035^2}{4} \quad = 2.88 * 10^{-3} m^3/s$$

$$Q = 2.88 * 10^{-3} * 0.8 * 1000 = 2.3\ kg/s$$

Continuity Equation:

Because the mass of a fluid flowing per second in a closed system must be constant, the previous equation for volume flow or mass flow may be restated for a system. If various parts of a system are indicated as 1 and 2 and 3, and the volume flow indicated as Q, then:

$$Q = A_1.v_1 = A_2.v_2 = A_2.v_2$$

This relationship is known as **the Continuity Equation**, which simply means that the multiple of velocity and cross-sectional area at any point in a closed system must be constant. This concept is important when calculating what is happening at one point in a system when the operating conditions elsewhere are known.

Example

A 250 mm diameter pipe carries water flowing at 87 litres per second. The main pipe divides into two pipes, each 100 mm diameter. Calculate the velocity in the smaller pipes.

Solution:

Assuming that the flow in each of the smaller pipes is equal and is half the main flow:

$$Q = A.v = \frac{0.087}{2} = v * \pi * \frac{0.1^2}{4} \Rightarrow v = 5.53m/s$$

Bernoulli Equation

The Bernoulli Equation is really a simple statement of the conservation of energy, applied to a fluid system. The fact that the energy level in a fluid system is constant allows us to predict what the pressure or the velocity will be at any point in the system.

Note: At this stage we are considering an ideal system - one where energy losses do not occur.

Considering two parts of the same system, identified by the suffixes 1 and 2, the Bernoulli Equation states:

$$P_1 + \rho g z_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g z_2 + \frac{1}{2}\rho v_2^2$$

where:

P is the pressure in newtons per square metre (or pascals)

v is the velocity in metres per second

z is the elevation in metres

You should write down the Bernoulli equation and add a sketch similar to Figure to illustrate the variables used, because it is used repeatedly in these notes and tests - you should be able to recall it under test conditions.

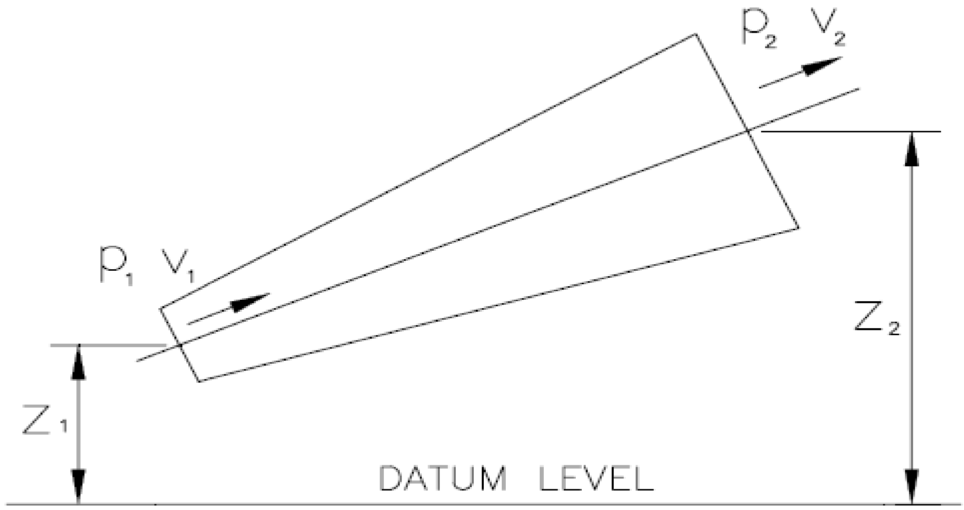


Fig. 4.1 Bernoulli Variables [7]

Just a few points that you should be aware of in connection with the Bernoulli equation:

* each term (pressure, velocity and elevation energy levels) has units of meters only, and is thus often called the pressure head, velocity head and elevation head

*in any use of the Bernoulli equation, always enter elevation (z) values relative to a datum level. Above the datum is positive elevation and below the datum is negative elevation

*in any system, always take the values sequentially in the direction of flow. This means, for a givensystem, the flow would be from z_1 to z_2 and then on to z_3 and so on

* when considering the energy levels at the surface of a liquid, remember that the velocity is zero, even if you are considering the velocity inside of a pipe that is collecting water from a surface

*when considering the pressure at the surface of a liquid, it is simpler to substitute zero (gaugepressure) than to calculate in terms of absolute pressure values. Also, you must realise that the pressure at the outlet to a pipe that is discharging to atmosphere (freely discharging) is zero gauge pressure.

Example

The diameter of a pipe changes gradually from 125 mm diameter bore at point A (which is 6 meters above a datum) to 60 mm bore at point B (which is 2 meters above a datum). The pressure in the pipe at A is 200 kPa absolute and the velocity at A is 2.8 m/s. If the fluid flowing is water, and neglecting losses, determine the pressure at B.

Solution:

First calculate the velocity at B. The flow is constant, so:

Q=$A_A.v_A$ =$A_B.v_B$

$$2.8 * \pi * \frac{0.125^2}{4} = v_B * \pi * \frac{0.06^2}{4} \Rightarrow v_B = 12.152\ m/s$$

Now substitute the values into the Bernoulli equation (leave in absolute units):

$$P_1 + \rho g z_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g z_2 + \frac{1}{2}\rho v_2^2$$

$$200 * 10^3 + 1000 * 9.81 * 6 + \frac{1}{2} * 1000 * 2.8^2 = P_2 + 1000 * 9.81 * 2 + \frac{1}{2} * 1000 * 12.152^2$$

$\Rightarrow \mathrm{P}_2 = 169.3$ KPa

Applications of Bernoulli's theorem:

a.Vase de Torricelli :

A fairly large reservoir is emptied through an orifice; the flow being done very slowly, we can neglect its unsteady character and consider the zero velocity at the surface of the fluid (just as with the naked eye we cannot see an infusion bag emptying) $\Rightarrow v_1 = 0$ et P_1=P_2=P_{atm}

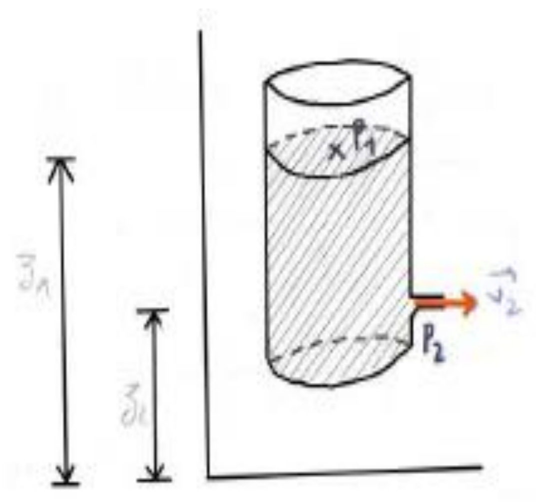


Fig.63: Emptying a tank. [7]

The Bernoulli equation:

$P_1 + \rho g z_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g z_2 + \frac{1}{2}\rho v_2^2$becomes :$P_{atm} + \rho g z_1 = P_{atm} + \rho g z_2 + \frac{1}{2}\rho v_2^2$

$\rho g z_1 = \rho g z_2 + \frac{1}{2}\rho v_2^2 \Rightarrow v_2 = \sqrt{2g(z_1 - z_2)} = \sqrt{2gH}$

b. Effect-Venturi:

For horizontal ducting, ie.for z1=z2

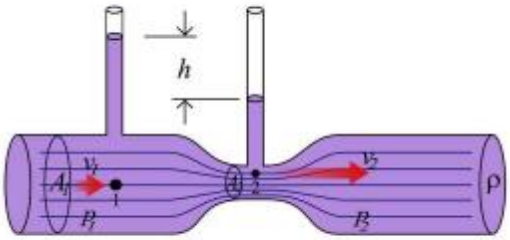


Fig.64: Horizontal Venturi tube[7]

Conservation of flow between (1) and (2):$A_1.v_1 = A_2.v_2 \Rightarrow v_1 = \frac{A_2}{A_1} v_2$

by asking$\alpha = \frac{A_2}{A_1}$, we have :$v_1 = \alpha . v_2$

$\alpha$is the degree of stenosis, "percentage" of arterial narrowing: α<1Ÿ

$\Rightarrow v_2 > v_1$:increase in speed in the narrowing

Conservation of energy between (1) and (2): for $z_1=z_2$, the Bernoulli equation becomes:

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

$$P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2)$$

$v_2 > v_1$,So$v_2^2 - v_1^2 > 0$ et $P_1 - P_2 > 0 \Rightarrow P_2 < P_1$: pressure drop in the constriction

Venturi-effect: “During a contraction, there is a drop in pressure, to the benefit of an increase in speed”

Chapter Nº. 04 Concept of Crystallography

Introduction

In nature, matter can exist in three different states (Figure I.1): gaseous state, liquid state and solid state. These states differ from each other by the interactions between its constituent particles (atoms, molecules or ions).

Liquids and gases are fluids that can be deformed under the action of very weak forces; they take the shape of the container that contains them. Solids, on the other hand, have their own shape and their deformation requires significant forces.

The solid state corresponds to a stack of chemical entities (atoms, molecules or ions), which occupy well-defined positions in space (except for internal and external vibrations). We distinguish two types of arrangements:

- Unordered solids, in which the assembly of entities does not exhibit long-range order, (Figure I.2.a).
- Ordered solids where, on the contrary, the assembly is very regular where the order would be

  Generalized in three dimensions, (Figure I.2.b).

Crystallography is the branch of science that studies crystalline matter at the atomic scale. It is primarily concerned with the spatial distributions of atoms or groups of atoms that are closely related to the physicochemical properties of a crystal.

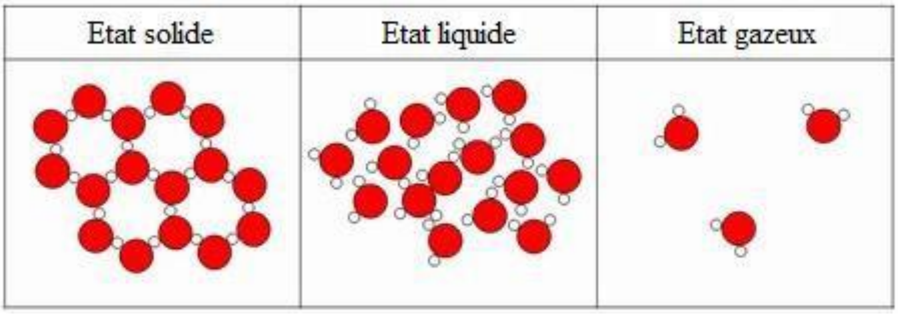


Figure I.1: Different states of matter. [10]

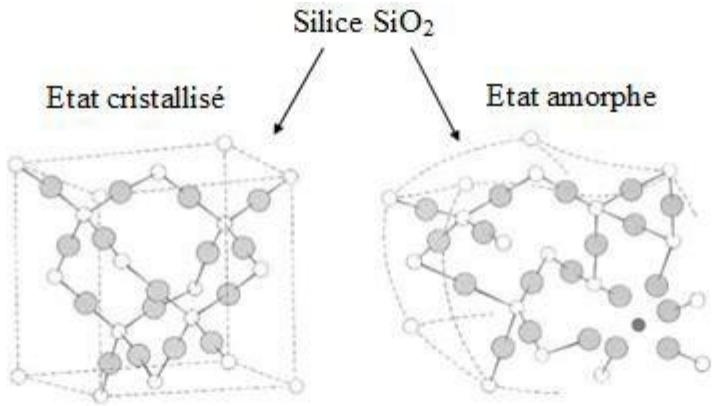


Figure I.2 : Representation of silica SiO_2 in its two states. a) ordered and b) disordered. [10]

Crystalline state

A crystal is a polyhedral solid, having plane faces that meet along straight edges (Figure I.3). It has a regular and periodic structure, formed by an ordered set of a large number of atoms (Figure I.4), molecules or ions. The crystalline state is not an isotropic state, like the liquid state where the properties are similar in all directions, but an anisotropic state where certain directions are favored.

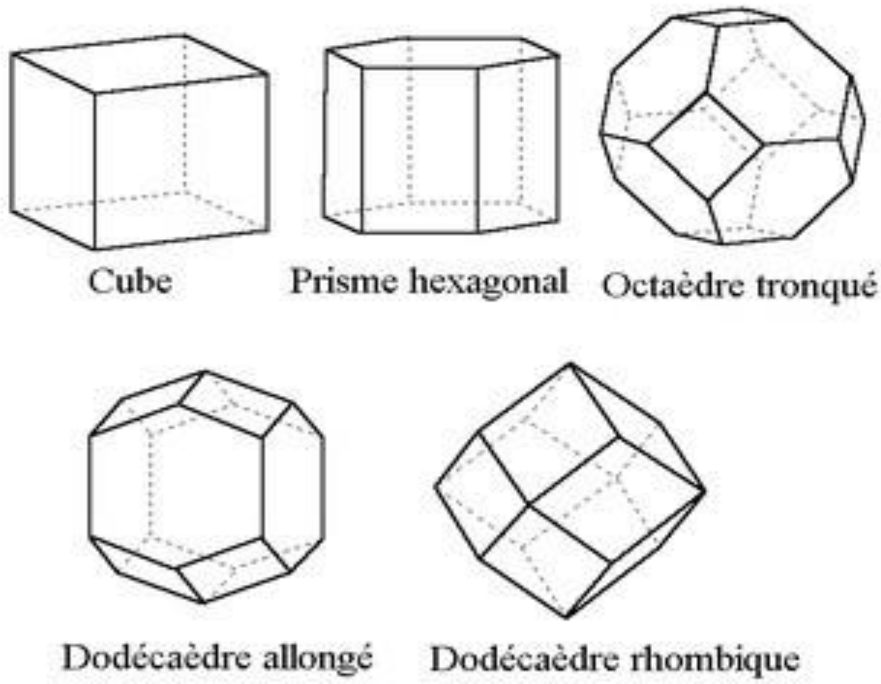


Figure I.3: Representation of some polyhedral shapes. [10]

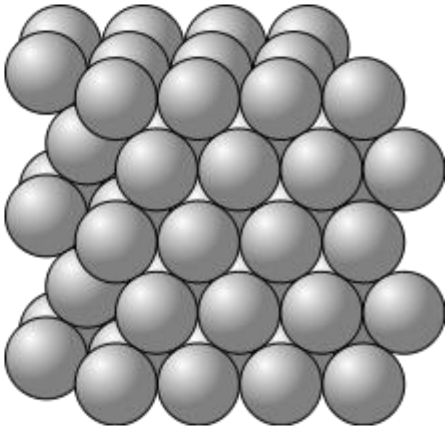


Figure I.4 : Arrangement of atoms in a crystal. [10]

Ideal crystal

The ideal or perfect crystal consists of a regular distribution of atoms, ions or molecules in the three dimensions of space and the regular arrangement of atoms extends practically to infinity. It can be characterized as the association of: a network of points obtained by translations; a pattern, the smallest discernible entity that repeats itself by translation.

Real Crystal

A real crystal contains a very large but finite number of atoms. It is not perfectly periodic because it has defects such as vacancies or dislocations. A real crystal (or polycrystal) is made up of several single crystals, called grains or crystallites (Figure I.5). These single crystals have different orientations and are separated from each other by grain boundaries.

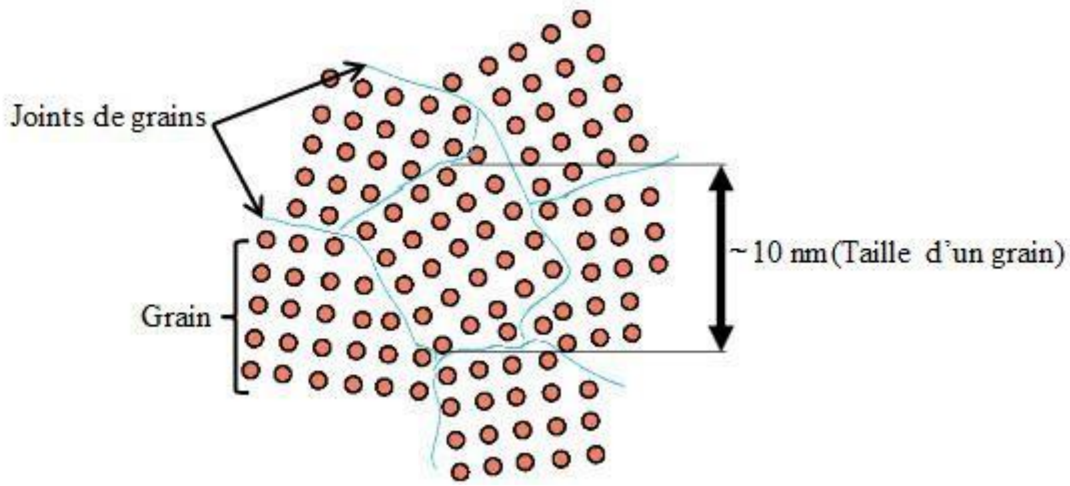


Figure I.5: Representation of a real crystal formed from several single crystals. [10]

Mesh, network, pattern and structure crystalline

Definition of the mesh

A cell is a basic parallelepiped unit from which the entire crystal can be generated solely by translations. It is defined by an origin "O" and three basis vectors $\vec{a}$, $\vec{b}$And$\vec{c}$. The lengths a , b, c are edges, and the measures α , β , γ are angles between the basis vectors (Figure I.6).

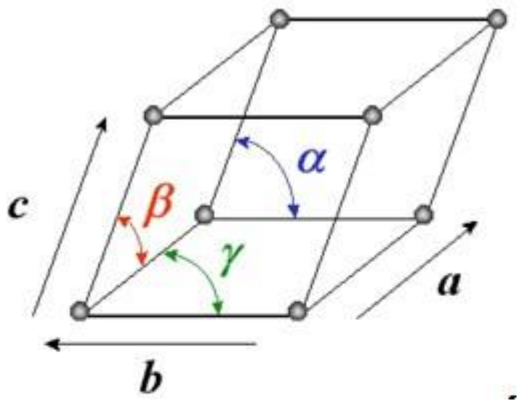


Figure I.6: Representation of a three-dimensional mesh. [10]

The choice of a mesh is not unique because there are an infinite number of meshes that can be chosen to generate a crystal. Among these , we call elementary or primitive mesh a mesh of minimal volume, given by the value of the mixed product of the three basic vectors, that is:

$$V=\left|\vec{a}.\left(\overrightarrow{b\wedge a}\right)\right|$$

Furthermore, the description mesh must show all the symmetries of the system, which is not always the case for the elementary mesh. It is then useful to consider a multiple or conventional mesh, comprising several nodes (which are not all located at the vertices of the mesh), clearly showing the symmetry of the structure. The number of nodes included in the mesh is called the order – or multiplicity – of the mesh. In Figure I.7, a primitive mesh of order 1 appears which contains only nodes at the vertices of the mesh. The multiple mesh of order 2 contains, in addition to nodes at the vertices, a node at the center of the volume.

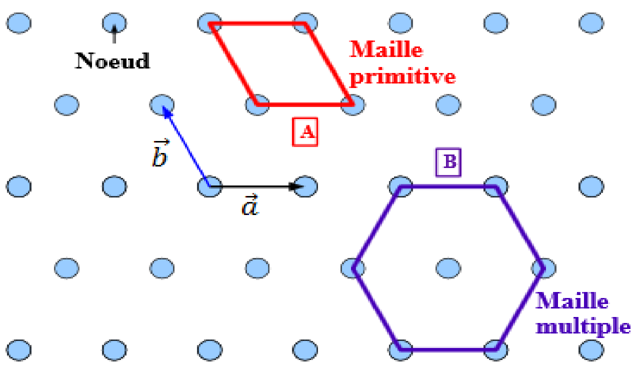


Figure I.7: Representation of different mesh shapes in a two-dimensional network. [10]

Wigner- Seitz mesh

The Wigner- Seitz mesh is the set of points that are closer to an origin node than to any other node (Figure I.8). The advantage of this mesh is that it is primitive and has the symmetry of the network. This is why it is used in physics. The disadvantage of this mesh is that it is not necessarily parallelepipedal (Figure I.9)

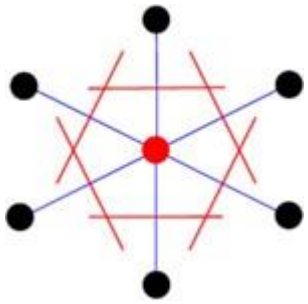


Figure I.8: Construction of a Wigner- Seitz mesh . [10]

Definition of network

A network is a set of equivalent points in space called nodes, generated by a translation by the basis vectors $\vec{a}, \vec{b}$ And$\vec{c}$. It is not a crystal. It is a set of points that has no materiality (Figure I.9). The set of points M forms the nodes of the network, occupied or not by particles. The origin " *O* " is a node, given by $x = y = z = 0$. The basis vectors are not unique for a network and the translation vector is given by the relation:

$$\vec{T} = u.\vec{a} + v.\vec{b} + w\vec{c}$$

Such that : *u* , *v* and *w* are three integers. $\vec{a}, \vec{b}$ And$\vec{c}$. are the three basis vectors following the three Space directions *Ox* , *Oy* and *Oz* , respectively.

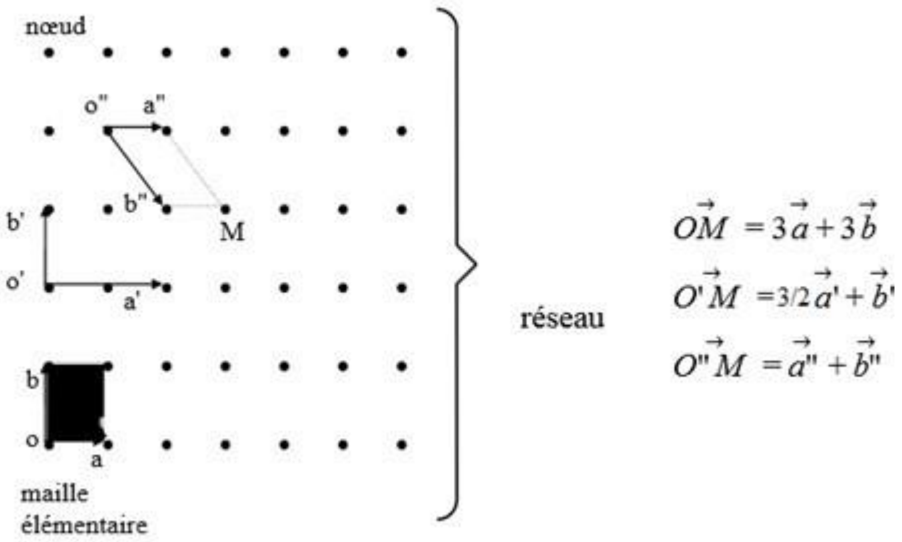


Figure I.9: Schematic representation of a network of nodes. [10]

Definition of the pattern

The pattern is the smallest discernible entity that repeats itself periodically by translation (Figure I.10). For a crystal, at the microscopic scale, the pattern is a set of particles, consisting of atoms, ions or molecules.

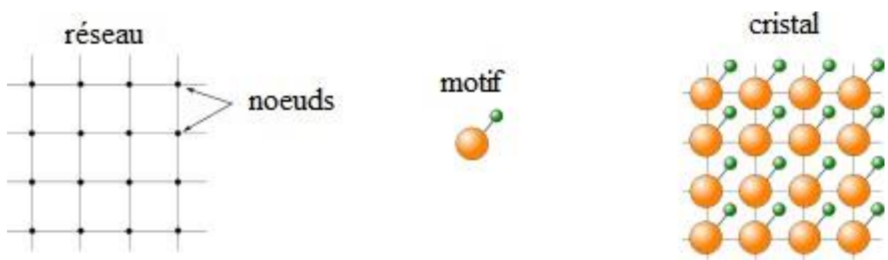


Figure I.10: Repetition of a pattern in two-dimensional space. [10]

Definition of the structure crystalline

In a simpler way, a crystal structure is formed by a network of nodes plus a motif (Figure I.11). Thus, for example, in a copper crystal, the motif is the copper atom. In a benzene crystal, the motif is a benzene molecule (and not a CH fragment). In a calcium carbonate crystal, the motif is formed by a calcium ion and a carbonate ion. In a calcium fluoride $CaF_{2\ crystal}$, the motif is formed by a calcium ion and two fluoride ions.

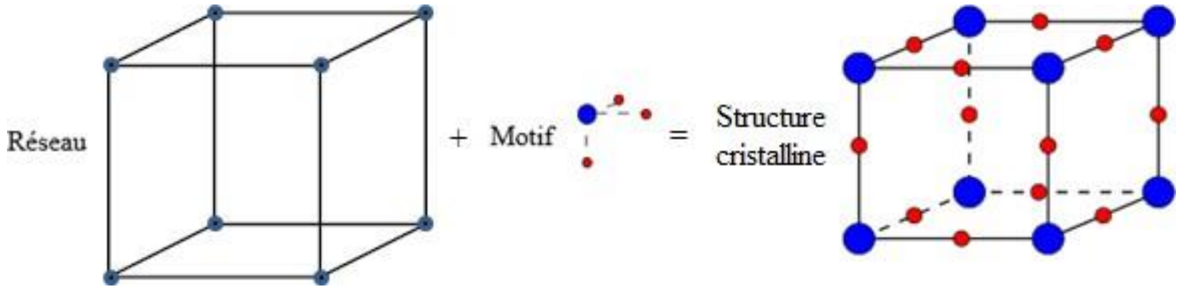


Figure I.11: Three-dimensional crystal structure . Symmetry and classification[10]

Crystallography is the classification of crystals according to their symmetry (symmetry will be discussed in Chapter II). Auguste Bravais (1848) showed that the number of possible crystal systems was very limited. He listed 14 types of lattices which are variants of only 7 crystal systems (Figure I.12).

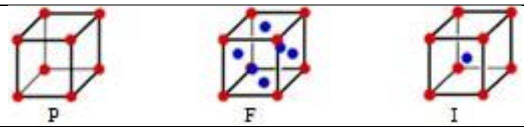
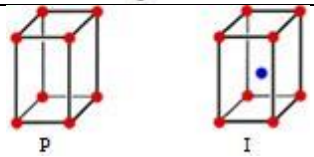
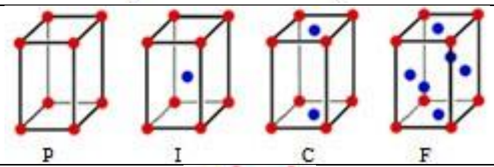
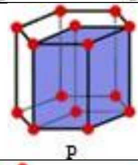
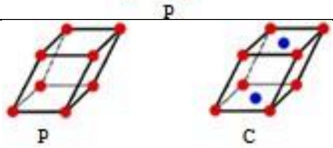
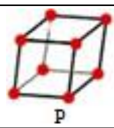
The 14 crystalline networks of Brallais	
Cubic system α = β = γ =90 ° a=b=c	
Tetragonal system α = β = γ =90 ° a= b ≠ c	
Orthorhombic system α = β = γ =90 ° a ≠ b ≠ c	
Hexagonal system α = β = 90° , γ = 120° a= b ≠ c	
Monoclinic system α = γ = 90° , β≠120° a ≠ b ≠ c	
Triclinic system α≠β≠γ≠ 90 ° a ≠ b ≠ c	
Rhombohedral system α = β = γ≠ 90 ° a=b=c	

Figure I.12: the 7 Bravais crystal systems

♦ ***Cubic system :***

- Simple cubic lattice (P): atoms present only at lattice points.

- Body-centered cubic lattice (I): there is an extra atom at the center of the cube.

- Face-centered cubic lattice (F): each face has an atom at its center .

♦ ***Hexagonal system:*** the hexagonal system can be broken down into rhomboid-based prisms (P).

♦ ***Orthorhombic system:*** simple (P), 2-face-centered (C), face-centered (F), centered prisms (I).

♦ ***Monoclinic system:*** simple (P), face-centered (F).

♦ ***Rhombohedral system:*** 1 single network (P).

♦ ***Tetragonal (quadratic) system :*** simple (P), centered (I).

♦ ***Triclinic system:*** 1 single network (P).

Plans reticular

We call reticular planes any family of planes parallel to each other containing all the nodes of the network (Figure I.13). In the usual space, the nodes can be grouped by equidistant parallel planes each containing an infinity of nodes . Such a plane is called a "reticular plane".

We call the "Miller indices" of the family of reticular planes the triplet (*hkl*) of the smallest natural integers that are coprime.

Three non-aligned nodes define a reticular plane . Furthermore, any node with coordinates (*u, v, w*) belonging to the family of reticular planes { hkl } verifies whatever the system of axes *Ox* , *Oy* and *Oz* the equation:

$$h\,u + kv + l\,\mathrm{w} = m$$

with *m* an integer that designates $^{\text{the}}$ *mth* family plan .

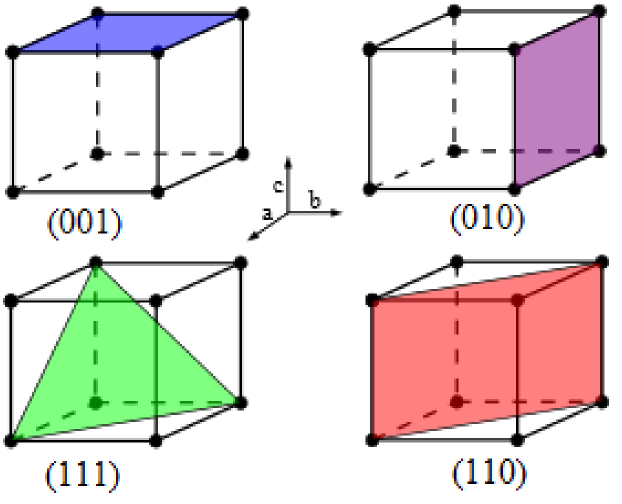


Figure I.13: Examples of reticular planes . [10]

Remarks :

- Plan indices are always enclosed in parentheses without separation.
- A negative index for example (- h) is denoted by ($\bar{h}$)
- A plane parallel to an axis intersects it at infinity, its Miller index corresponding to this

  Axis is equal to 1/α= 0.
- A family of plans (hkl) is denoted by a curly bracket { hkl }.

Example :

Consider the face shown in the figure below; determine the Miller indices (hkl) of this face.

Methodology :

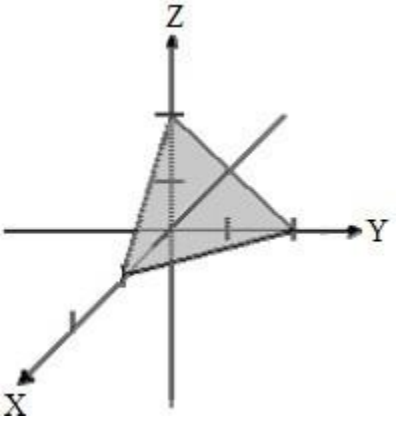
Find the intersections of the plane on the axes *Ox* , *Oy* and *Oz*

A (1, 2, 2)

Take the inverse of these three numbers B(1/1,1/2,1/2) Reduce them to integers having the same denominator

C(2/2,1/2, 1/2)

The Miller indices are therefore: (211)



Rows reticular

Let be a vector $\vec{R} = A.\vec{a} + B.\vec{b} + C\vec{c}$, of origin “O” (Figure I.14). The notation of a row (direction) can be done by indices generally noted u , v , w obtained by dividing the coordinates of $\vec{R}(A\ \ ,\ \ , C\ \ )$ by an integer such that u , v and w are integers and the smallest possible.

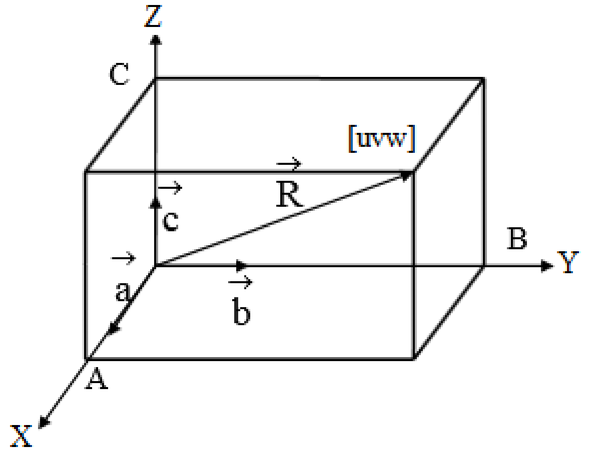


Figure I.14: Representation of a reticular row. [10]

The row is denoted by the indices in brackets [*uvw*]. The opposite direction will be denoted [$\bar{u}\,\bar{v}\,\bar{w}$] .

In the cubic system, the directions :

[111] , [$\bar{1}11$] , [$1\bar{1}1$] , [$11\bar{1}$] , [$\bar{1}1\bar{1}$] , [$\bar{1}\bar{1}1$] , [$1\bar{1}\bar{1}$] , [$\bar{1}\bar{1}\bar{1}$]

Are crystallographically identical .

Thus the set of equivalent directions in the cube is represented by < *uvw* >, or <111>.

Coordination

Definition

The A/B coordination of a crystal is the number of nearest neighbor B atoms of the atom HAS.

<u>Example :</u>

<u>Polonium crystal coordination</u>

For polonium the Po/Po coordination is 6 (Figure I.15).

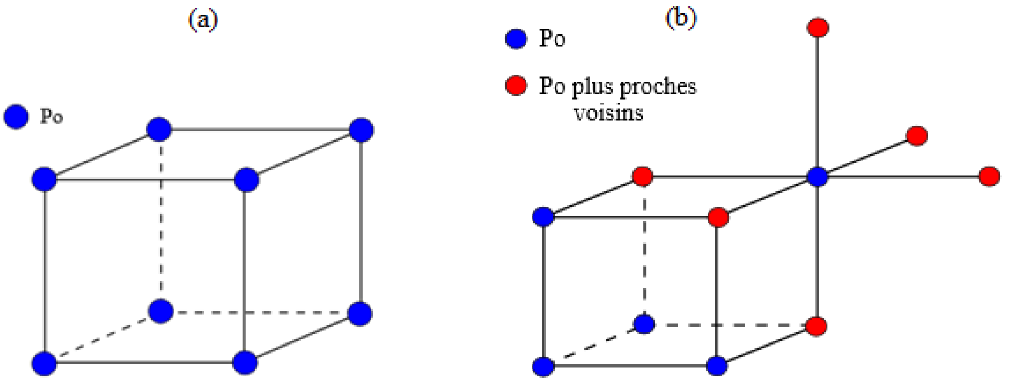


Figure I.15: (a) Polonium crystal. (b) Polonium coordination . [10]

Compactness or density stacking

The compactness C of a crystal is the relative volume occupied by the atoms of the pattern in the cell. The constituents of the crystal (atoms) behave like rigid and non-deformable hard spheres. In this case, the compactness is given by the relation:

$$C = \frac{mV_{motif}}{Vmaille}$$

Where m is the multiplicity of the mesh, $V_{pattern}$ the volume of the pattern and V_{mesh} the volume of the mesh.

Example :

Polonium compactness

We place ourselves within the framework of the model of tangent hard spheres.

$$V_{maille} = a^3 V_{motif} = \frac{4}{3}\pi R^3$$

La tangence des plus proches voisins (Figure 16) donne : $a = 2R$ d'où :

$$C = \frac{1}{8R^3} \times \frac{4\pi R^3}{3} \Leftrightarrow C = \frac{1}{6} \approx 0.52 \text{ (Pour le polonium } m = 1\text{)}$$

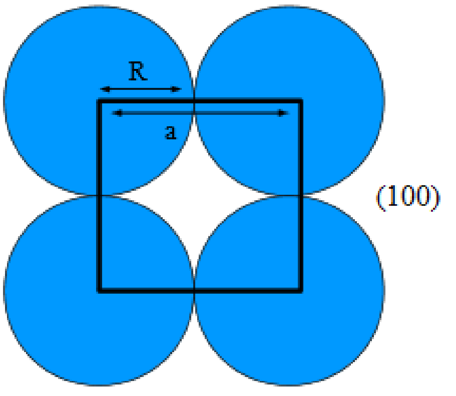


Figure I.16: Compactness of Polonium. [10]

Mass volumetric

The density ρ of the crystal is defined by :

$$\rho = \frac{m \times m_{\,motif}}{Vmaille}$$

Where *m* is the multiplicity of the mesh.

<u>Example :</u>

<u>Density of polonium crystal</u>

For polonium, the tables give *a* = 335.2 pm and M $_{Po}$ = 209 g.mol^{-1}

$$m_{motif} = m_{Po} = \frac{M_{Po}}{N_A} \quad avec\ N_A = 6.02 \times 10^{23}$$

$$\rho_{Po} = \frac{M_{Po}}{N_A a^3} \qquad A.N:\ \underline{\rho_{Po} = 9.22 \times 10^3 kg.m^{-3}}$$

Bibliography

1-Physique rappels de cours & Exercices corrigés ; M. Benabdoun et T. Dehdouhédition de l'université Mentouri Constantine 2005/2006.

2-100 years of dimensionalanalysis: new stepstowardsempiricallawdeduction ,Mtaylor , A I Diaz ,Jodar-Sanchez and R J Villanneva –Mico.

3-https://fr.wikipedia.org/wiki/Constante_physique.

4-Cours de physique optique, cours et exercices avec solution dunod paris 1997Jean-Paul porisat

5-Cours Physique Optique. J-P. Parisot, P. Segonds, S. Le Boiteux.Sciences Sup, Dunod 2003.

6-Cours de physique – Optique.A. Moussa et P. Ponsonnet .EdDesvigne, Paris 1992.

7-Cours et Exercices de PHYSIQUE Générale Amari Sihem et Belfedal Abdelkader.Office des Publications Universitaires :I.S.B.N : 978. 9961.

8-http://fr.wikipedia.org/wiki/Structure_cristalline.

9-http://fr.wikipedia.org/wiki/Cristallographie.

10-Introduction à la physique des solides.Emanuel MooserPremière édition, 1993. Presses polytechniques et universitaires romandes, CH-1015 Lausanne.

11- Polycopiés ‘’ Recueil d’exercices corriges ‘’.Amarisihem. Département du tron commun SNV . (2021).

12- Handbook of applied Hydraulics. Davis et Sorensen.

Series of TDs

I. Analyse dimensionnelle

Exercice N° 01

- Etablir les dimensions et les unités des grandeurs suivantes :

Vitesse (V), accélération (a), force (F), travail (W), Energie cinétique (E_c), puissance (P), constante de pesanteur (g), Pulsation (ω), fréquence (f).

Exercice N° 02

Dire lesquelles de ces formules sont homogènes:

- l longueur, g champ de pesanteur, T temps:

$$T=2\pi\sqrt{\frac{l}{g}} \qquad T=2\pi\sqrt{\frac{g}{l}} \qquad T=2\pi\sqrt{\frac{(l+g)}{lg}}$$

- p quantité de mouvement (masse multipliée par vitesse), m masse, c vitesse de la lumière, E énergie:

$$E=\sqrt{pc^2+m^2c^4} \qquad E^2-\frac{p^2c^2}{m}=m^4 \qquad E^2=p^2c^2+m^2c^4$$

Exercice N° 03 (même cas avec l'exercice précédent)

La période T d'un satellite terrestre circulaire peut dépendre, a priori, de m la masse de la Terre, du rayon R du cercle décrit et de la constante de la gravitation universelle G. On peut faire l'hypothèse que la période T a pour expression : $T = K\, m^a\, R^b\, G^c$ ou K est une constante sans dimension.

- Déterminer, par une analyse dimensionnelle, les valeurs de a, b et c sachant que la dimension d'une force est $[F] = M.L.T^{-2}$. En déduire l'expression de la formule de la période T.

Exercice N° 04

Soit la formule $Y=A.X^4+B.X^3+C.X^2+D$

Avec :$[Y] =M.L^{-1}.T^{-1}$ et X est une longueur.

Quelles sont les équations aux dimensions de A.B.C et D.

Exercice N° 05

Montrer que les grandeurs suivantes sont sans dimension.

$$\boldsymbol{R=\frac{\rho v d}{\eta}}\ , \qquad \boldsymbol{C_p=\frac{Pd}{\rho\, v^2 L}}$$

Ou : v: est la vitesse du fluide, **ρ** : la masse volumique, **η** : viscosité dynamique, **d** :diamètre, **L** : longueur , P: pression.

II. Analyse vectorielle

Exercice 1 :

Dans un plan muni d'un repère orthonormé, on place les points A(2,4), B (-1,-2).

1) Calculer les coordonnées du vecteur $\overrightarrow{AB}$.

2) Calculer la norme du vecteur $\overrightarrow{AB}$ (valeur exacte).

Exercice 2 :

Soient les vecteurs : $\vec{V}_1 = 2(\vec{\imath} + \vec{\jmath} + \vec{k})$, $\vec{V}_2 = -\vec{\imath} + 2\vec{\jmath} + 3\vec{k}$, $\vec{V}_3 = \vec{\imath} + 2\vec{\jmath} - 2\vec{k}$

a- Représenter graphiquement les vecteurs $\vec{V}_1$ $\vec{V}_2$ $\vec{V}3$,définis sur R^3.

b- Trouver les modules des vecteurs : $\vec{V}_1$, $\vec{V}_1 + \vec{V}_2$, $\vec{V}_2 - \vec{V}_3$

c- Déterminer les angles $(\vec{V}_1, \vec{V}_2)$, $(\vec{V}_1, \vec{V}_3)$ et $(\vec{V}_2, \vec{V}_3)$

Exercice 3 :

On considère les vecteurs $\vec{A} = 2\vec{\imath} + \vec{\jmath} - 3\vec{k}$, $\vec{B} = \vec{\imath} - 2\vec{\jmath} + \vec{k}$ et $\vec{C} = -\vec{\imath} + \vec{\jmath} - 4\vec{k}$. Déterminer les produits suivants :

a- $\vec{A} \cdot (\vec{B} \times \vec{C})$

b- $\vec{C} \cdot (\vec{A} \times \vec{B})$

c- $\vec{A} \times (\vec{B} \times \vec{C})$

d- $(\vec{A} \times \vec{B}) \times \vec{C}$

Exercice 4 :

$(\vec{\imath}, \vec{\jmath}, \vec{k})$ étant les vecteurs unitaires des axes rectangulaires(Oxyz).on considère les vecteurs $\vec{V}_1 = 6\,\vec{\imath} + 8\vec{\jmath} + 26\vec{k}$, $\vec{V}_2 = \vec{\imath} + \vec{\jmath} + \vec{k}$ et $\vec{V}_3 = 2\,\vec{\imath} + 3\vec{\jmath} - \vec{k}$

1) calculer l'aire du parallélogramme qu'on peut construire à partir des vecteurs $\vec{V}_1$ et $\vec{V}_2$

2) déterminer l'angle **θ** que font les vecteurs $\vec{V}_1$ et $\vec{V}_2$.

3) calculer le volume du parallélépipède construit sur les trois vecteurs.

Exercice 5 :

Déterminer la valeur du nombre a pour laquelle les vecteurs $\vec{V}_1 = 2\vec{\imath} + a\vec{\jmath} + \vec{k}$ et $\vec{V}_2 = 4\vec{\imath} - 2\vec{\jmath} - 2\vec{k}$ soient perpendiculaires.

III. Calcul d'erreurs et incertitudes

Exercice N°01

Pour mesurer l'épaisseur e d'un cylindre creux, vous mesurez le diamètre intérieur D1 et le diamètre extérieur D2 et vous trouvez D1 = 19.5 ± 0.1 mm et D2 = 26.7 ± 0.1 mm. Donnez le résultat de la mesure de e avec son incertitude absolue puis la précision (incertitude relative).

Exercice N°02

Calculez l'aire S d'un disque dont le rayon vaut R = 5.21 ± 0.1 cm. Quelle est la précision du résultat obtenu ?

Exercice N°03

Vous mesurez la longueur, la largeur et la hauteur de la salle de physique et vous obtenez les valeurs suivantes : Longueur 10.2 ± 0.1 m largeur 7.70 ± 0.08 m hauteur 3.17 ± 0.04 m Calculez les grandeurs suivantes et donnez les résultats avec leurs incertitudes absolues : a) le périmètre p b) la surface S du sol c) le volume V de la salle.

Exercice N°04

Pour déterminer la masse volumique d'un objet vous mesurez sa masse et son volume. Vous trouvez m = 16.25 g à 0.001 g près et V = 8.5 ± 0.4 cm3 . Calculez la masse volumique ρ avec son incertitude absolue puis la précision du résultat.

Exercice N°05

La calculatrice d'un étudiant donne le résultat x=6.1234, sachant que x présente une incertitude relative de 2% .Exprimer la réponse sous la forme standard $x_m \pm \Delta x$ correctement arrondie. Combien de chiffres significatifs doit avoir la réponse ?

Exercice N°06

Déterminer l'incertitude absolu et relative sur la quantité de chaleur Q libérée par effet joule dans un calorimètre de masse m de capacité C_p, de température initiale T_1 et de température finale T_2 ($T_2 > T_1$). La formule de la quantité de chaleur est donné par : $Q = mC_p(T_2 - T_1)$

On donne : m= (500±1) g ; Cp= (4.02±0.03) calorie/ (g°C) ; T_2= 40.1°±0.1° ; T_1=20.0°±0.1°

Exercice N°07

La densité (δ) d'un corps solide par application du théorème d'Archimède est :

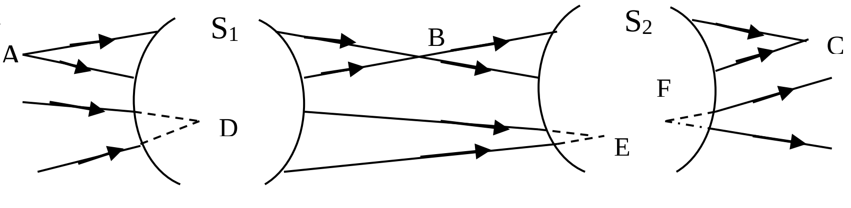
$$\delta = \frac{m_2 - m_1}{m_3 - m_1}$$

Où $m_3, m_1\ et\ m_3$ sont les résultats de trois mesures de masses effectuées, successivement, avec la même balance. Trouver l'incertitude relative sur δ.

I. Réfraction + Dioptre plan + Miroir plan

Exercice N° 01

Considérant les systèmes optiques (S_1) et (S_2). Préciser la nature des points (A, B, C, D, E, F) de la figure 1.

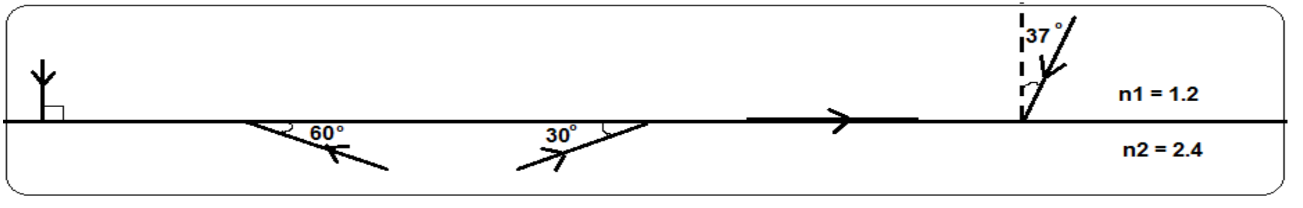


Exercice N° 02

Un faisceau de lumière se propage dans l'air et pénètre dans l'eau sous une incidence de 30°. Une partie de la lumière est réfléchie et le reste est réfracté. Déterminer la direction prise par les deux faisceaux émergents.

Exercice N° 03

Construire dans chaque cas proposé, le rayon réfléchi et le rayon réfracté, en précisant les angles de réflexion et de réfraction.



Exercice N° 04

I. On considère un rayon de lumière qui passe de l'air au verre. Il arrive avec un angle d'incidence i=25° sur l'interface air/verre. On donne : $n_{air}=1$ et $n_{verre}=1,5$

1- Dans quel milieu la vitesse de la lumière est-elle la plus élevée ?

3- Calculer l'angle de réfraction r avec lequel le rayon passe dans l'air.

4- Donner un schéma, sans respecter la valeur de l'angle, en indiquant si le rayon s'écarte ou s'éloigne de la normale.

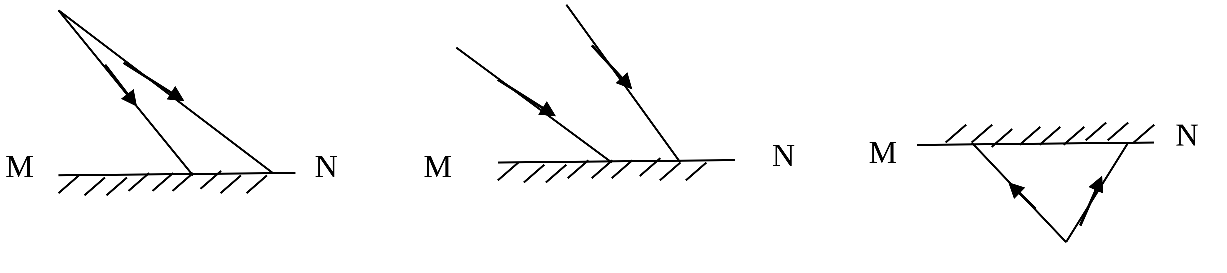
5- Existe-t-il, dans le cas du passage de l'air au verre, un rayon réfracté pour tout rayon incident ? Justifier.

II. On considère un rayon de lumière qui passe du verre à l'air. Il arrive avec un angle d'incidence i=25° sur l'interface verre/air. On donne : $n_{air}=1$ et $n_{verre}=1,5$

(Même questions avec la partie précédente)

Exercice N° 05

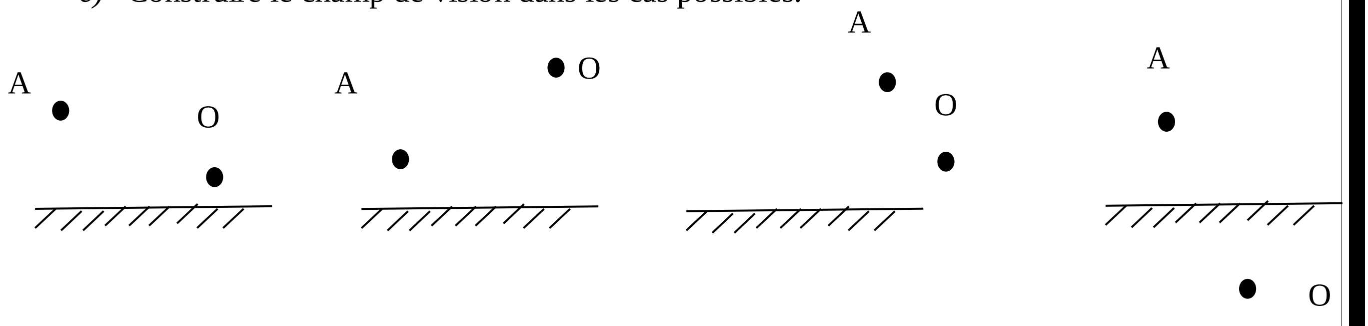
Construire le faisceau lumineux dans chaque cas de figure. Préciser la position et la nature des points objets et images.



Exercice N° 06

Considérant un miroir plan de largeur MN, un point objet réel A et l'œil O d'un observateur.

a) Construire A' et O' les images respectives de A et de O à travers le miroir.
b) L'œil voit-il l'image A' ?si oui, tracer le rayon lumineux qui part de l'objet A et atteint l'œil O après s'être réfléchi sur le miroir.
c) Construire le champ de vision dans les cas possibles.



Exercice N°7 :

Un poteau vertical de hauteur h = 2.7m est planté au bord d'un bassin, de profondeur uniforme H=1.8m. Les rayons du soleil font un angle de 42° avec la verticale.

- Calculer l'ombre portée du poteau sur le fond du bassin:
  a- Si le bassin est vide.
  b- Si le bassin est rempli d'eau (n=4/3).

Exercice N°8 :

L'œil d'un poisson placé en A, à 60cm de la surface de l'eau. A la verticale de A se trouve un pêcheur dont l'œil est en B , a 90cm de la surface de l'eau (n = 4/3).

A- A quelle distance le pêcheur voit-il l'œil du poisson ?
B- A quelle distance le poisson voit-il l'œil du pêcheur ?
C- Tracer dans chaque cas la marche d'un pinceau lumineux qui permet a l'un de voir l'œil de l'autre.

II. Miroir Sphérique, Dioptre Plan, Association de Dioptres Plans et Sphériques.

Exercice N° 01

- En utilisant les deux méthodes (graphique et calcul), déterminer la position, la taille et le sens de l'image d'un objet $\overline{AB}$ $(5cm)$, perpendiculaire à l'axe d'un miroir concave de rayon 20cm et se trouvant aux distances suivantes :

a-30 cm b-20 cm c-10 cm d-5 cm

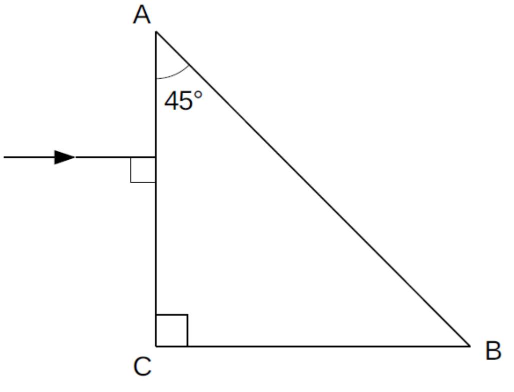
- Même question avec un miroir convexe (cas de 10cm) .

Exercice N° 02

- Les rayons lumineux, issus d'un point A, traversent une lame à faces parallèles, se réfléchissent sur un miroir qui lui est parallèle puis, la traversent a nouveau.
- Construire l'image A' de A, donnée par le système (lame à faces parallèles +miroir plan).

Exercice N° 03

- 1. Compléter le chemin du rayon lumineux qui entre dans le prisme :



- 2. Le prisme est maintenant plongé dans l'eau.
  Compléter le chemin du rayon lumineux qui entre dans le prisme.
  On donne : 1,33 : indice de réfraction de l'eau.

Exercice N° 04

- Le prisme d'un spectroscope à un angle au sommet de 60°.son indice de réfraction, pour la lumière jaune du sodium est de 1.751.
- dans ce prisme, baignant dans l'air (n'=1), déterminer la déviation minimale de la lumière du sodium ainsi que l'angle d'incidence correspondante i_m.
- on fait arriver, sur le même prisme et sous l'incidence précédente i_m.la lumière d'un tube d'hydrogène, formée d'une radiation rouge et d'une autre bleue pour lesquelles les indices

de réfraction du prisme sont respectivement,1.742 et 1.769.déterminer l'angle que font les rayons rouge et bleu à la sortie du prisme.

Exercice N° 05

- Une lentille mince convergente a 5cm de distance focale. Déterminer par le calcul et par la construction graphique la nature, la position et la grandeur de l'image d'un objet de 5mm et situé à 4cm de la lentille.
- Calculer la vergence de cette lentille.
- Même travail avec une lentille divergente

Exercice N° 06

Un objet AB est placé dans le plan focal objet d'une lentille convexe de 20cm de distance focale. De l'autre coté, à 10cm de la lentille, on place un miroir plan perpendiculaire à l'axe principal.

- Trouver graphiquement les caractéristiques de l'image donné par le système.

Practical work Protocols (TPs)

I. Calculs d'Erreur et Incertitudes

1. Objectifs de TP

• Apprendre à estimer une incertitude de mesure.

• Savoir représenter un résultat de mesure.

• Maitriser l'utilisation des instruments de base de mesure de longueur.

• Calculer les surfaces et volumes d'objets de différentes formes.

2. Incertitudes dans les mesures

Toute mesure d'une grandeur physique présente inévitablement une incertitude. Elle résulte de diverses erreurs qui peuvent être classées en deux grandes catégories: les erreurs systématiques, qui se produisent toujours dans le même sens et les erreurs aléatoires, qui sont variables en grandeur et en sens et dont la moyenne tend vers zéro.

L'origine de ces erreurs provient essentiellement de trois facteurs:

- l'expérimentateur ;
- l'appareil de mesure (fidélité, sensibilité et justesse) ;
- la méthode de mesure.

Il convient de chercher à éliminer les erreurs systématiques et d'évaluer les erreurs aléatoires.

* On peut essayer d'estimer l'incertitude a priori sur une détermination "unique", mais en s'appuyant sur une bonne connaissance du système.

* On peut étudier la précision globale d'une mesure à partir d'une étude statistique.

La deuxième méthode pourra être utilisée pour l'interprétation au niveau d'un groupe. Il est bien clair qu'une étude statistique ne sera d'aucun secours pour traiter des erreurs systématiques.

3. Incertitude sur une mesure directe

a) <u>Incertitude absolue</u>

Elle représente la plus grande valeur absolue de l'erreur commise sur une mesure. Si g est le résultat de la mesure G, l'incertitude absolue sera notée □g. Nous écrirons:

$G = g \mp \Delta g$ ou $g - \Delta g \leq G \leq g + \Delta g$.

b) <u>Incertitude relative (taux d'incertitude)</u>

On souhaite comparer la précision de deux mesures ; on considère pour cela la quantité $\Delta g / g$. La mesure est d'autant plus précise que ce rapport est faible. On l'exprime souvent en %.

4. Incertitude sur une grandeur calculée

Le plus souvent, on veut déterminer une grandeur G qui dépend de grandeurs X, Y, ... mesurables. On dispose alors d'une relation g = f(x, y,...) et il nous faut déterminer g connaissant f(x, y,...), x, y, Δx, Δy,... On peut y parvenir assez facilement en ne considérant que les variations au premier ordre, approximation acceptable si Δx, Δy,... sont petits par rapport à x, y,..., et utiliser le calcul différentiel. Il y a deux règles simples à mettre en œuvre et facile à démontrer: les incertitudes relatives (en %) des deux facteurs d'une multiplication ou d'une division s'ajoutent, les incertitudes absolues des deux termes d'une somme ou d'un produit s'ajoutent.

Par la suite, pour simplifier, nous considérerons une grandeur G dont la valeur g dépend des deux mesures x et y supposées indépendantes ; f(x, y) est supposée être alors une différentielle totale exacte, d'où:

$$dg = \left(\frac{\partial g}{\partial x}\right)_y dx + \left(\frac{\partial g}{\partial y}\right)_x dy$$

Le passage à l'incertitude absolue consiste à prendre la somme des valeurs absolues:

$$\Delta g = \left| \frac{\partial g}{\partial x} \right|_y \Delta x + \left| \frac{\partial g}{\partial y} \right|_x \Delta y$$

Quelques exemples:

g = A x + B y dg = A dx + B dy Δg = A Δx + B Δy

.

g = A x - B y dg = A dx - B dy Δg = A Δx + B Δy

.

Pour des expressions du type produit ou rapport, il est commode de faire appel à une différenciation logarithmique:

g = A x y ln g = ln A + ln x + ln y dg/g = dx/ x + dy/y

$$\Delta g / |g| = \Delta x / |x| + \Delta y / |y|$$

g = A x/y ln g = ln A + ln x - ln y dg/g = dx/x - dy/y

$$\Delta g / |g| = \Delta x / |x| + \Delta y / |y|$$

Toute expression plus complexe pourra être traitée comme une combinaison des quatre exemples présentés ou bien directement en la différenciant. Ces méthodes sont souvent implantées directement dans des programmes informatiques de traitement statistique de données expérimentales.

II. Partie expérimentale

3. MANIPULATION

3.1. Mesures répétées de longueurs avec une règle.

Mesurer quatre fois la longueur d'un plateau de paillasse (désigné par le chargé de TP), en procédant de la même manière et avec le même soin (en évitant notamment l'erreur de parallaxe**)**. Porter les valeurs mesurées dans le tableau ci-dessous.

	1ère mesure	2ème mesure	2ème mesure	2ème mesure	L_{moy}
Longueur L du plateau					
Incertitude d'Instrument					
$L_{mes}-L_{moy}$					

a. Quelle estimation peut-on faire de l'incertitude liée à la sensibilité de l'instrument de mesure utilisé (règle) ? À quelle catégorie d'incertitudes relève-t-elle ?

b. Compléter le tableau en calculant la moyenne des valeurs mesurées (Lmoy) et l'écart (L_{mes} -L_{moy}), pour chaque mesure ; en déduire l'incertitude absolue correspondant à la dispersion des valeurs mesurées et l'incertitude absolue globale sur la mesure.

c. Écrire le résultat de la mesure avec l'incertitude absolue correspondante selon la forme d'encadrement standard L = (Lmoy ± ΔL)unité, en faisant attention au nombre de chiffres significatifs retenus.

3.2 MESURE DE LONGUEURS D'ORDRE DE GRANDEURS DIFFERENTS

Mesurer la largeur (*l*) et l'épaisseur (e) du même plateau en utilisant l'échelle normale E_1 de la règle (Graduée en millimètres). Refaire la mesure de l'épaisseur en utilisant l'échelle plus fine E_2 de la règle (Graduée en ½ mm) puis le pied à coulisse (P.A.C.) au 1/10 de mm. Porter les valeurs mesurées dans le tableau ci-dessous.

Grandeur a mesurer	Instrument Utilisé	Valeur mesurée (mm)	Incertitude Absolue (mm)	Incertitude Relative (%)
Largeur (l)	**Règle E1**			
Epaisseur (e)	**Règle E1**			
Epaisseur (e)	**Règle E2**			

Epaisseur (e)	P.A.C			

3.3 MESURE DE LONGUEURS D'OBJETS DE FORMES DIFFERENTES

Nous disposons de trois objets : une sphère, un parallélépipède et un cylindre, en utilisant le pied à coulisse au 1/50 de mm, mesurez :

1. La longueur L, la largeur l, et la hauteur h du parallélépipède. Estimer les incertitudes ΔL, Δl et Δh. Calculez le volume du parallélépipède V et son incertitude ΔV en cm^3. Ecrire le résultat sous la forme standard.

2. Le diamètre d de la sphère. Estimer l'incertitude Δd. Calculer la surface S en cm^2 et le volume V en cm^3 ainsi que les incertitudes ΔS et ΔV. Ecrire les résultats sous la forme standard.

3. Le diamètre D, la hauteur H du cylindre. Estimer les incertitudes ΔD et ΔH. Calculer le volume du cylindre et son incertitude. Ecrire le résultat sous la forme standard.

<u>Feuille De Réponse</u>

Ecrivez les valeurs avec 2 chiffres après la virgule.

<u>Expérience ; 01</u>

Mesurez 4 fois la longueur ***L*** d'une table en utilisant des différents instruments et complétez le tableau ci-dessous.

N^{mbr} de mesures	L1	L2	L3	L4

Li (cm)				
L_{moy} (cm)				
ΔL mesuré (cm)				

On Donne :ΔL(instrument) = 0.50mm **ΔL(**lecture)= 0.50mm

ΔL= …………………

L= (………..…±………..…..)

<u>Expérience ; 02</u>

.Mesurez l'épaisseur ***e*** de la même table avec 2 instruments et complétez le tableau

-E1 : règle graduée en (mm) **Δe**inst =0.50mm **Δe**lect=0.50mm

-E2 : pied à coulisse en (mm) **Δe**inst= 0.05mm**Δe**lect = 0.00 mm

instruments	Epaisseurs (mm)			**e_{moy}** (mm)	Δe (mm)	**Δe/e_{moy}** %
	e1	**e2**	**e3**			
E1						
E2						

Donner la présentation standard de**e1**, **e2** et

e1=…………….…………

e2=………………..………

Parmi les 2 instruments, le quel donne une mesure précise, dite pourquoi ?

……...……………………………………

………

………

……...……………………………………

………

Expérience ; 03

A l'aide d'un pied à coulisse mesurer le rayon ***R*** d'une sphère 3 fois et complétez le tableau.

	Ri (cm)	**R_{moy} (cm)**	**ΔR(cm)**	**La surface de la sphère S_{moy} (cm^2)**
Sphère				

On utilisant l'opération sur les incertitudes, calculer Δ***S*** et écrivez et donner la présentation standard de ***S***

………

………

………

………

………

………

………

Quels sont les facteurs qui causent les erreurs dans un laboratoire ?

………

………

………

………

Conclusion : évaluez ce qui limite la qualité de la mesure.

………
……

TP N°02 REFLEXION and REFRACTION

1. Purpose of the practical work

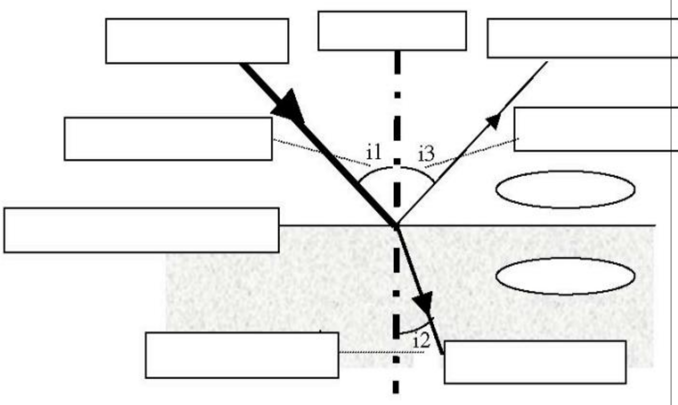
• Know the vocabulary used in optics

• Know the phenomenon of reflection.

• Understand the phenomenon of refraction of light when crossing the separation surface of two different transparent media.

• Determination of the refractive index of different transparent media (Dioptres).

- **1. Principle**



• A diopter is a separation surface between two media.

• A transparent medium is characterized by its optical index nmilieu. The optical index is the ratio between the speed of light in a vacuum and that in the medium.

• The higher the optical index, the more refractive the medium.

• The optical index of air is equal to nair = 1.00.

1. Label the diagram above by indicating the incident, reflected and refracted rays; the plane diopter and the normal to the diopter; the angles of incidence, reflection and refraction.

2. Is there another diopter in the assembly? What is its geometry? Why this choice? Justify after having drawn the normal to the diopter for the refracted ray.

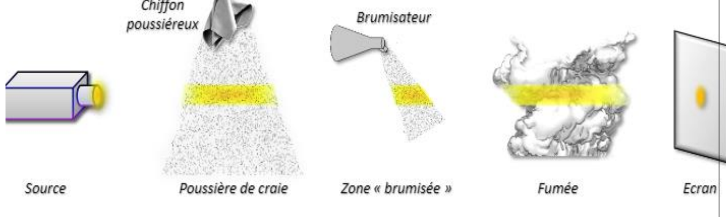
3. Give the relationship between the optical index and the speeds of propagation of light in the different media.

1. **Manipulation**

1- Propagation and visibility of a beam of light

- *How does light propagate in a transparent, homogeneous and isotropic medium?*

  Disperse chalk dust on a beam of light from a laser directed towards a



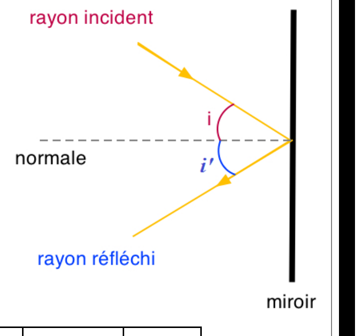
screen.

- *What do you observe? Conclude*

2- A pencil in a glass of water (broken stick experiment)

Place a pencil in a glass half-filled with water and look at the two objects from different points of view.

What do you observe? Conclude



1- The reflection (Mirror)

1. How is the ray reflected relative to the plane of incidence?
2. Deduce the first law of Snell-Descartes on reflection.
3. For different angles of incidence measure the angle of reflection. Give the results in the following table:

Angle of incidence (i)	*80°*	*70°*	*60°*	*50°*	*40°*	*30°*	*20°*	*10°*	*0°*
Angle of reflection (i')									

1. Compare the angles of incidence and reflection. Deduce Descartes' second law of reflection.

2- Refraction (Glass Diopter)

1- How is the ray refracted relative to the plane of incidence?
2- Deduce Descartes' first law on refraction.
3- For different angles of incidence measure the angle of refraction.
4- Give the results in the following table and calculate:

Angle of incidence (i)	*80°*	*70°*	*60°*	*50°*	*40°*	*30°*	*20°*	*10°*	*0°*
Sin (i)									
Angle of reflection (r)									
Sin (r)									

1- Compare the angle of incidence and the angle of refraction.

2- For each of the boxes in the table, calculate the ratio siniairsiniplexi.

3- What do you observe? Deduce the second law of Snell-Descartes on refraction.

4- Plot the curve of the variation of Sin(i) =f(sin(r)).

5- Deduce the refractive index of the glass used.

6- Deduce the limiting angle of refraction.

7- Can we have total reflection with this device?

Repeat the same previous work by changing the glass diopter for another in water, deduce the refractive index of this water.

NOM PRENOM ET GROUPE :

1/…………………………………………………………………………

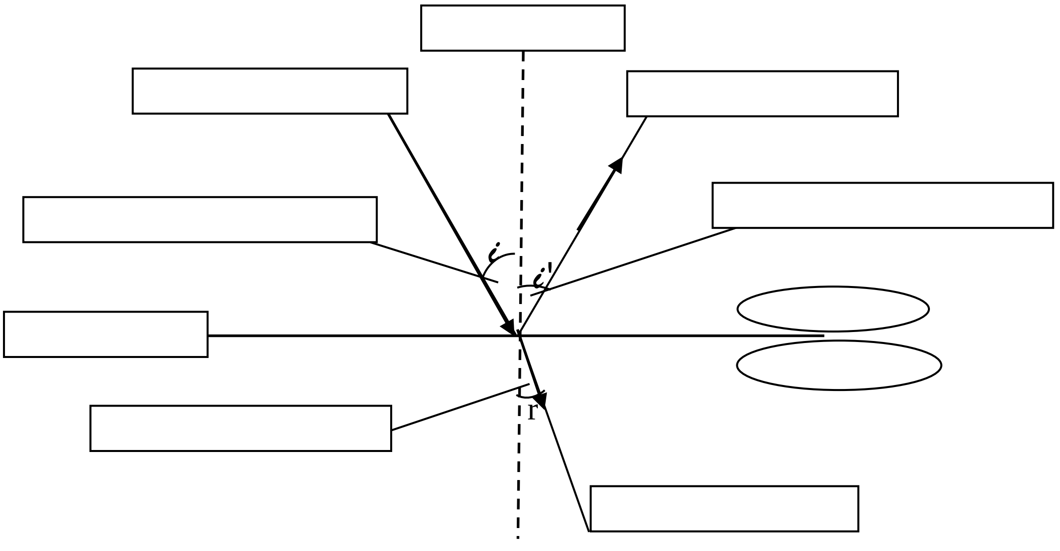
2/…………………………………………………………………………

3/…………………………………………………………………………

4/…………………………………………………………………………

5/…………………………………………………………………………

1-légender le schéma ci-dessous



2- Donner les lois de snell-descartes pour :

- La réflexion :……………………………………………………..………………………………
……
- La réfraction :………………………………………………………..…………………………
………

3-comment se propage la lumière dans un milieu transparent homogène et isotrope ?dites pourquoi ?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………….

<u>Expérience 01</u> : réflexion (miroir)

-Mesurer les angles de réflexions et compléter le tableau suivant :

Angles (i)					
Angles (i')					

-Déterminer l'incertitude absolue et relative

…………………………………………………………………………………………………
…………………………………………………………………………………………………

…………………………………………………………………………………………
…………………………………………………………………………………………

-Comparer les angles d’incidence et ceux de réflexion.

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………..

<u>Expérience 02</u>Réfraction (dioptre en verre)

a/Mesurer les angles réfractés et compléter le tableau suivant

Angles (i)					
Sin(i)					
Angles (r)					
Sin (r)					
$n_{verre}=\frac{\sin(i)}{\sin(r)}$					

Déterminer l’incertitude absolue et relative sur l’angle (r)

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
………………………………………………………………

b/ Comparer les angles d’incidence et ceux de réfraction

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
……………………………………………………………

c/ tracer la courbe de variation sin(i)=f(sin (r))

d/Apartir du graphe déduire l’indice de réfaction du verre

……………………………………………………………………
……………………………………………………………………
……………………………………………………………………
……………………………………………………………………
……………………………………………………………………
……………………………………………………………………
……………………………………………………………………..

e/ déduire l’angle de réfraction limite

……………………………………………………………………
……………………………………………………………………
……………………………………………………………………
……………………………………………………………………
……………………………………………………………………
……………………………………………………………………

CONCLUSION

....
....
....
....
....
....
....
....
....
....
....
......

exam subjects

Examen de Physique

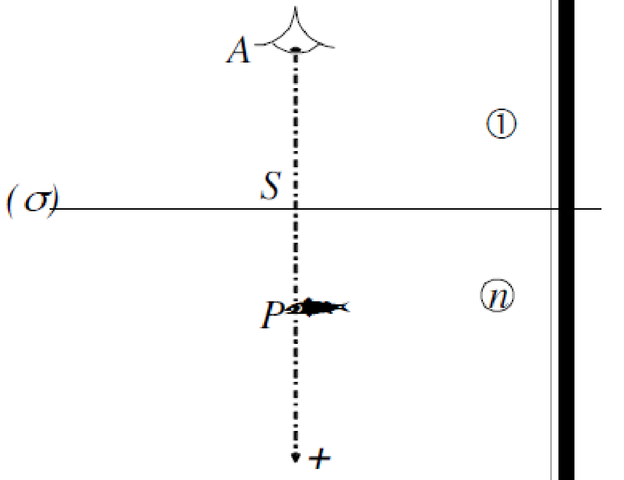
Exercice 01 ***(07.50pts)***

- Un rayon lumineux voyage dans le vide avec une fréquence $\boldsymbol{\upsilon_0=4{,}62.10^{14}}$**Hz** et rencontre un milieu d'indice **n=1.5**

1- Calculer $\boldsymbol{\lambda_0}$ sa longueur d'onde dans le vide.
2- Calculer $\boldsymbol{\lambda}$ sa longueur d'onde dans ce milieu.
3- Calculer **V** sa vitesse dans le milieu.
4- Calculer $\boldsymbol{\upsilon}$sa fréquence dans ce milieu.
5- De quelle couleur est cette radiation ?

- On donne les longueurs d'onde dans le vide: Le rouge entre **625nm** et **740nm** et le violet entre **380nm** et **446nm.** La vitesse de la lumière dans le vide est **c = 3.10^{8}m/s**

<u>Exercice 02</u> (05.50pts)



- Une cuve contient de l'eau dont la surface libre est***(σ).*** A la verticale de **(σ)**un observateur regarde un poisson (point *P*) situé à la profondeur $\overline{SP}$ ***= 80 cm*** *(voir figure ci-contre).* On prendra un indice *1* pour l'air et ***n*** **= 4/3** pour l'eau.

1- Montrer, à l'aide d'un schéma, que l'observateur voit le poisson à une profondeurdifférente de la profondeur réelle.

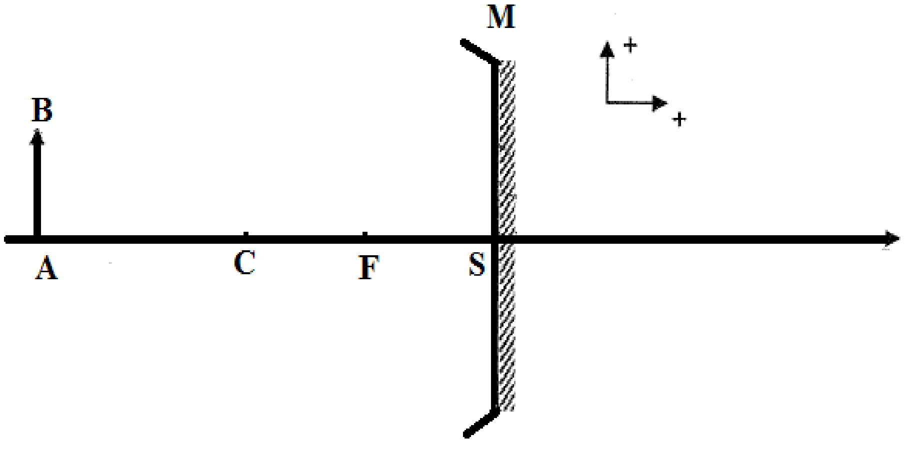
- On pourra considérer l'approximation des petits angles.

2- Montrer que la profondeur apparente dupoisson est $\overline{SP'}=\frac{1}{n}\overline{SP}$

3- Calculer cette profondeur apparente.

<u>Exercice 03</u>(07pts) **Constructions géométriques (graphiques)**

Construire l'image A'B' (réelle ou virtuelle) de l'objet AB (réel ou virtuel), préciser pour chaque cas la nature de l'objet AB et de l'image A'B' et le grandissementγ.

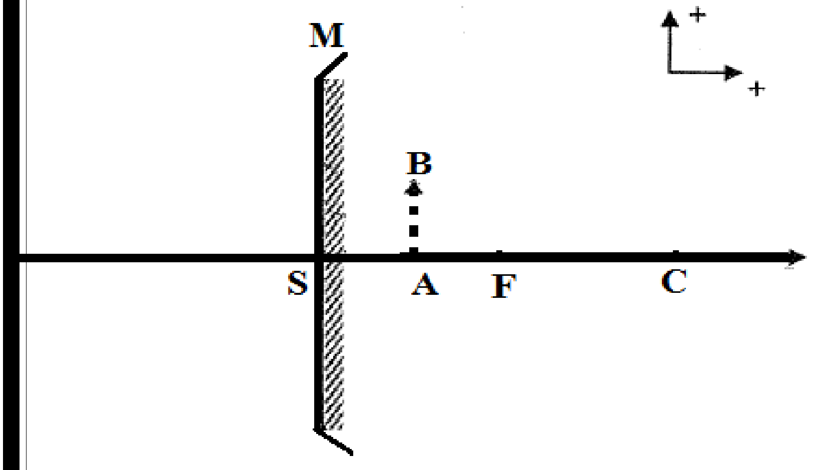


M: Miroir sphérique concave

AB: Objet reel droit

A'B': Image réelle renversée

Le grandissement:$|\gamma|< 1$

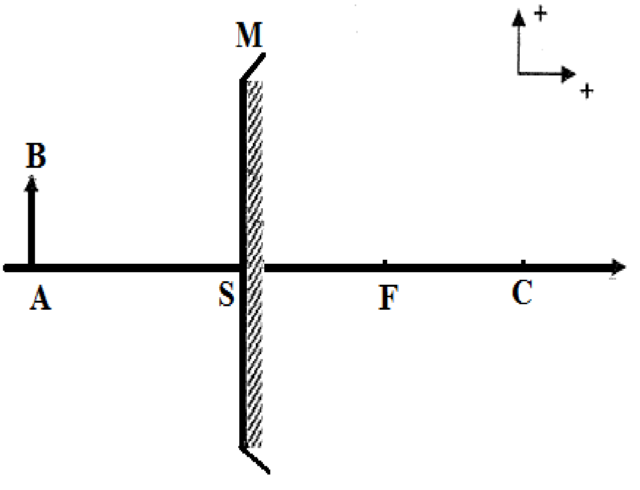


M:……………………………….

AB:……………………………...

A'B':…………………………….

Le grandissement:$|\gamma|$ **…. 1**

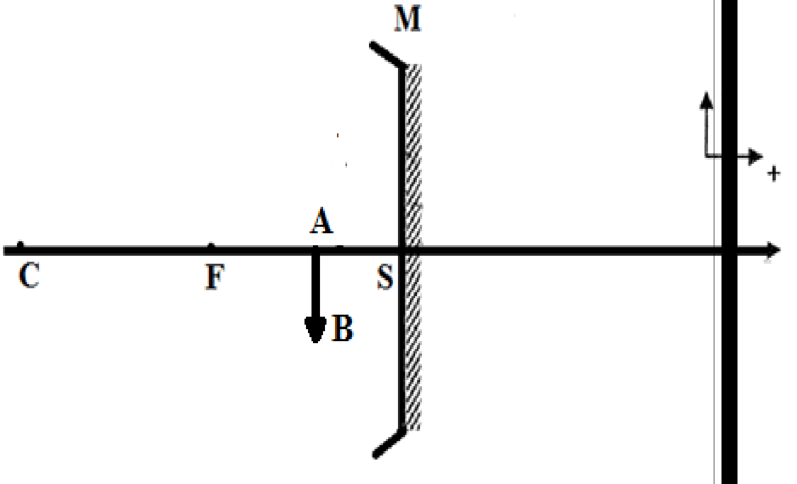


M: …………………………….

AB: ………………………...

A'B': …………………….

Le grandissement:$|\gamma|$ **……. 1**



M:Miroir sphérique concave

AB: …………………………...

A'B': ………...……………….

Le grandissement:$|\gamma|$ **……. 1**

Examen de Physique

Exercice 01 ***(10pts)*** **:** Mettre une croix sur le petit carré placé à coté de la bonne réponse et répondre aux questions suivantes:

Question 1 : Soit la formule: $\boldsymbol{f = a + \frac{b+c}{d.e}}$ avec :

$[f] = L^2M^{-1}, [b] = L^{-2}M^{-1}T^2, [d] = LMT^3$

□ La dimension de e est: $\boldsymbol{L^{-5}T^{-1}M^{-1}}$

□ La dimension de a est: $\mathbf{L^2M^{-2}}$

□ La dimension de c est: $\boldsymbol{L^{-1}M^{-1}T^2}$

□ L'unité de mesure de f est: $\mathbf{Kg/m^2}$

□ L'unité de mesure de a est: $\mathbf{m^2Kg^{-1}}$

□ L'unité de mesure de e est: $\mathbf{m^5s^{-1}}$

□ L'unité de mesure de b est: $\mathbf{m^2s^2Kg^{-1}}$

□ L'unité de mesure de c est: $\mathbf{Kg^{-3}s^2}$

Question 2 : La vitesse moyenne des particules d'un fluide à température T et de masse m est donnée par la formule: $\boldsymbol{v(T,m) = \sqrt{\frac{8KT}{m}}}$ *(K est une constante sans dimension)*.Trouver l'incertitude relative sur la vitesse:

....
....
....
....
....
....

Question 3 : La formule de Cauchy simplifiée, donnant l'indice d'un verre (sans unité), pour une radiation monochromatique de longueur d'onde λ *(exprimé en nm)*, est : $\boldsymbol{n = A + \frac{B}{\lambda^2}}$ où *A* et *B* sont des constantes.

Trouver les equations aux dimensions de A et Bet leurs unités de mesures.

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
………
……………………………………………………………………………………………
…

Question 4: Soit un tronc conique de hauteur h, de rayons r et R. la formule qui donne son volume est:

□ a. V= $2\pi(R-r)\frac{h}{3}$ □ b. V= $\frac{\pi h}{3}(rR+r^2+R^2)$ □ c. V= $\frac{\pi h}{3}(r^2-R+R^2)$ □ d. V= $\frac{\pi h}{3}(2-\frac{r}{R})^2$

Question 5: La fréquence de vibration d'une goutte d'eau peut s'écrire sous la forme : $\boldsymbol{f = k.R^{\alpha}.\rho^{\beta}.\tau^{\gamma}}$

où $\boldsymbol{k}$ est une constante sans dimension, $\boldsymbol{R}$ est le rayon de la goutte, $\boldsymbol{\rho}$ sa masse volumique. $\boldsymbol{\tau}$ est la tension superficielle définie par une force par unité de longueur.

Par une analyse dimensionnelle trouver les constantes α, β et γ , en déduire l'expression de la formule de la période T.

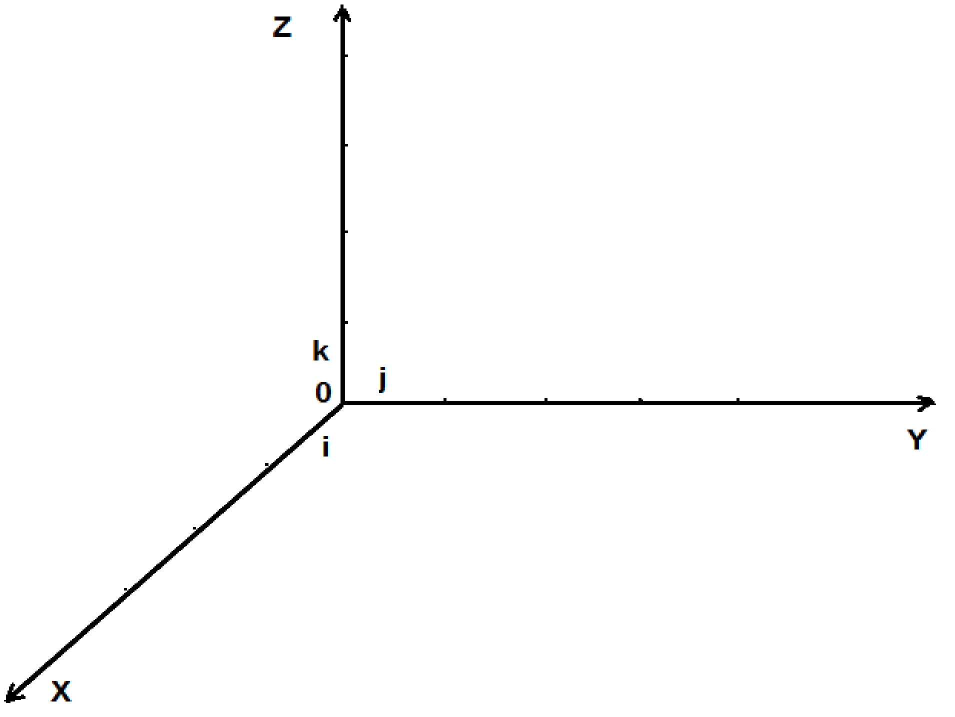
……………………………………………………………………………………………
…
……………………………………………………………………………………………
…
……………………………………………………………………………………………
…
……………………………………………………………………………………………
…
……………………………………………………………………………………………
…

Exercice 02 **(10pts)**

Dans un repère orthonormé OXYZ, on considère les trois vecteurs suivants:

$\vec{V}_1$= $3\vec{\imath}+\vec{\jmath}-\vec{k}$, $\vec{V}_2$= $-\vec{\imath}-2\vec{\jmath}+2\vec{k}$, $\vec{V}_3$= $-2\vec{\imath}-3\vec{\jmath}+\vec{k}$

1- Représenter graphiquement les vecteurs $\vec{V}_1$, $\vec{V}_2$ et $\vec{V}_3$.



2- Calculer les produits suivants:

a- $\vec{V}_1.\vec{V}_2$

b- $\vec{V}_1 \Lambda \vec{V}_2$

3- Calculer le volume du parallélépipède engendré par les vecteurs, $\vec{V}_1$, $\vec{V}_2$ et $\vec{V}_3$ (Montrer le dans la représentation en dessus).

Examen de physique

<u>Exercice 01</u> ***(10.5pt)*** ***Questionnaire:*** Mettre une croix sur le petit carré placé à coté de la bonne réponse

<u>Question 1</u>:

Un Observateur est placé à 2m d'un miroir plan vertical:

1- La distance qui le sépare de son image est:

□ a) $\overline{OA} = 02m$ □ b) $\overline{AA'} = 02m$ □ c) $\overline{OA'} = 04m$ □ d) $\overline{A'A} = 04m$

2- Il s'éloigne de 50cm, la distance objet image devient :

□ a) $\overline{OA} = 05m$ □ b) $\overline{AA'} = 05m$ □ c) $\overline{OA'} = 0.5m$ □ d) $\overline{A'A} = 0.5m$

2- Il revient à sa position initial, puis on éloigne le miroir de 50cm, limage se déplace par rapport a lui par une distance de:

□ a) $\overline{A"A'} = 01m$ □ b) $\overline{A"A'} = 02m$ □ c) $\overline{A"A'} = 04m$ □ d) $\overline{A"A'} = 05m$

Question 2 :

Soit la formule: $\boldsymbol{f = a + \frac{b+c}{d.e}}$ avec :

$[f] = L^2M^{-1}, [b] = L^{-2}M^{-1}T^2, [d] = LMT^3$

□ La dimension de e est: $\boldsymbol{L^{-5}T^{-1}M^{-1}}$

□ La dimension de a est: $\mathbf{L^2M^{-2}}$

□ La dimension de c est: $\boldsymbol{L^{-1}M^{-1}T^2}$

□ L'unité de mesure de f est: $\mathbf{Kg/m^2}$

□ L'unité de mesure de a est: $\mathbf{m^2Kg^{-1}}$

□ L'unité de mesure de e est: $\mathbf{m^5s^{-1}}$

□ L'unité de mesure de b est: $\mathbf{m^2s^2Kg^{-1}}$

□ L'unité de mesure de c est: $\mathbf{Kg^{-3}s^2}$

Question 3 :

- La vitesse limite atteinte par un parachute est une fonction de son poids P et de sa surface S est: $\boldsymbol{V = \sqrt{\frac{P}{K.S}}}$

1- Les dimensions de la constante K

□ [K] = ML^{-2} □ [K] = ML^{-1} □ [K] = ML^{-3} □ [K] = LM^{-3}

2- l'unité de mesure de K

□ K≡($Kg.m^{-2}$) □ K≡($Kg.m^{-1}$) □ K≡($Kg.m^{-3}$) □ K≡($m.Kg^{-3}$)

3- La vitesse limite d'un parachute ayant les caractéristiques suivantes :

m = 90 kg, S = 80 m^2, g = 9,81 m/s^2, et k = 1,15 MKS.

□ V=3.09m/s □ V=4.09m/s □ V=12.8m/s □ V=80m/s

- Dans le cas précédent ΔP est (2 %) et ΔS (3 %).

4- La formule de l'incertitude absolue ΔV sur la vitesse,

□ $\Delta V = (\frac{1}{2}\left|\left(\frac{\Delta P}{P}\right) + \left(\frac{\Delta K}{K}\right) + \left(\frac{\Delta S}{S}\right)\right|)$. □ $\Delta V = (\frac{1}{2}\left|\left(\frac{\Delta P}{P}\right) + \left(\frac{\Delta K}{K}\right) + \left(\frac{\Delta S}{S}\right)\right|)$.V □ $\Delta V = \left|\left(\frac{\Delta P}{P}\right) + \left(\frac{\Delta S}{S}\right)\right|$.V

5- La valeur de l'incertitude absolue ΔV sur la vitesse,

□ $\Delta V = 5.14.10^{-4}$m/s, □ $\Delta V = 6.14.10^{-4}$m/s, □ $\Delta V = 7.14.10^{-4}$m/s, □ $\Delta V = 8.14.10^{-4}$m/s

6- La formule de L'incertitude relative $\frac{\Delta V}{V}$,

□ $\frac{\Delta V}{V} = \frac{1}{2}\left|(\frac{\Delta P}{P}) + (\frac{\Delta K}{K}) + (\frac{\Delta S}{S})\right|$ □ $\frac{\Delta V}{V} = \frac{1}{2}\left|\left(\frac{\Delta P}{P}\right) + (\frac{\Delta S}{S})\right|$ □ $\frac{\Delta V}{V} = \left|(\frac{\Delta P}{P}) + (\frac{\Delta K}{K}) + (\frac{\Delta S}{S})\right|$

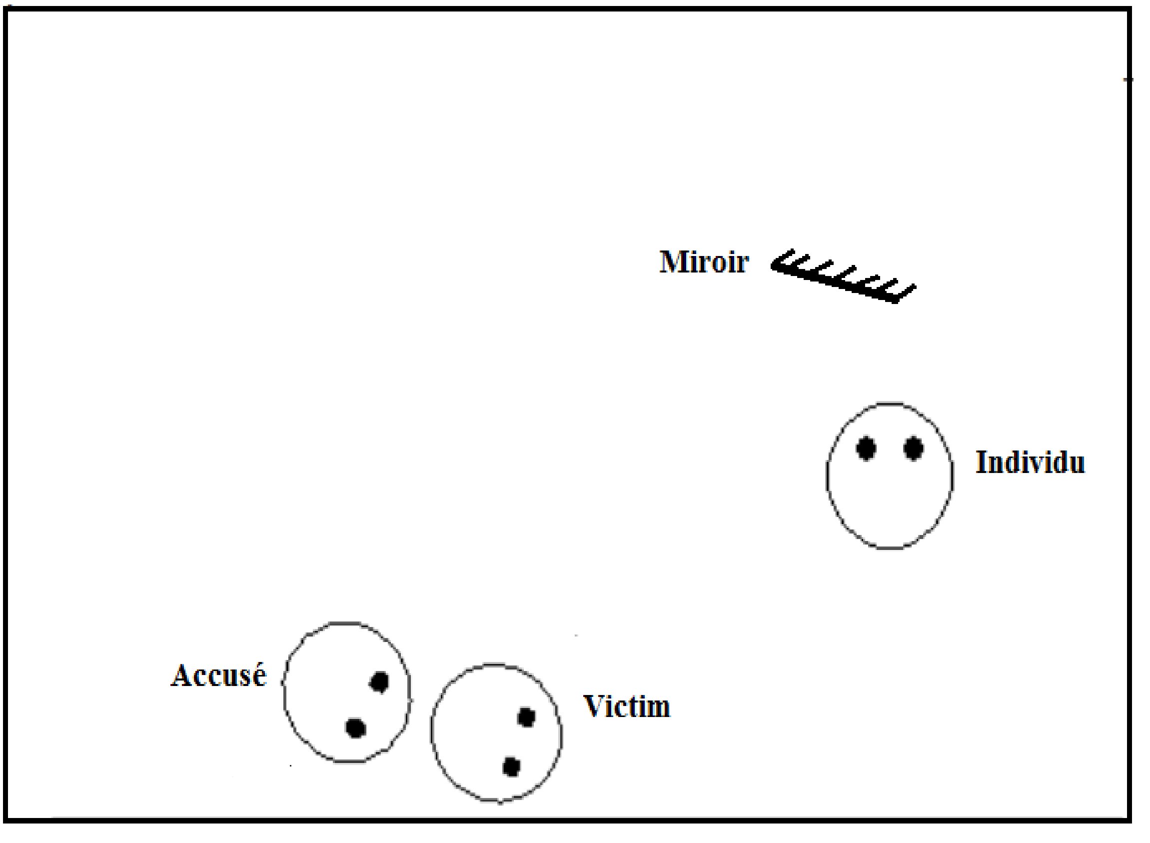
7- La valeur de l'incertitude relative (sachant que la constante K et la gravité g n'ont pas d'incertitude).

□ 0.01 % □ 0.02 % □ 0.20 % □ 1.00 % □ 10.00 %

Exercice 02 (09.5pt) Constructions géométriques (graphiques)

A- Lors d'un procès, on vous charge d'analyser la véracité d'un témoignage important pour incriminer l'accusé, qui aurait volé un porte-feuille dans un magasin. Un individu situé devant le miroir plan d'une petite boutique dit avoir vu l'accusé voler la victime par le miroir. La situation a été recréée sur le schéma ci-dessous.

1- Construire l’image de l’individu donnée par le miroir
2- L’individu pouvait-il voir le visage du voleur?
…………………………………………………………………………………
…………………………………………………………………………………
…………………………………….



B- Deux miroirs plans sont perpendiculaires, construire le rayon lumineux qui issu de A passe par B après réflexion sur les deux miroirs **M_1**et **M_2**