Democratic and Popular Algerian Republic

Ministry of Higher Education and Scientific Research

Echahid Hamma Lakhdar University of El-Oued

Faculty of Science and Technology

Sector: Electromechanics

(1st master 's degree in electromechanics)

Course materials

" Industrial Mechanisms and Power Transmission "

Detailed module program

Chapter 01: General

Kinematic connections between mechanical parts.

Standardization .

Chapter 2: Making Connections

Dismountable assembly.

Permanent assembly .

Chapter 3 : Rotation Guidance

Plain bearings.
Guidance by interposition of bearings.
Hydrostatic and hydrodynamic bearings.

Chapter 4: Translation Guidance

Guidance by direct contact.
Guidance by interposition of rolling elements.
Waterproofing and connection protection function.

Chapter 5: Organs of transmission of Movements and power

Coupling.
Clutch.
Brake.
Gear transmission.
Belt transmission.

Course prepared by
MEZIANE.Assia

Course Objectives

At the end of this course the student will be able to:

- Provide the knowledge and skills to interpret standards, work methods, drawings and diagrams.
- Know the skills necessary for the application of basic techniques in mechanical assembly and movement guidance (in rotation and translation).

- Differentiate the means of transmitting the movement of certain mechanisms and machine parts.
- Apply assembly, installation and troubleshooting techniques to engine transmission devices and their accessories.
- Create adjustments necessary for the proper functioning of a mechanism.

Prerequisites

To get the most out of this course you need to know:

- Basic notions of technical drawing.

- Applied mechanics .

Chapter 1: General

1. General Introduction:

The role of mechanical construction is to produce technical objects necessary for human life. All human activities: living, clothing, housing, moving, communicating, etc. require the intervention of the technical object; element artificial replacing natural elements or improving their performance.

In his daily life, today's man commonly uses technical objects: household appliances, clothing, homes, vehicles, telephones, televisions. The technician, creator of these objects, must have exhaustive knowledge of them to perfect them in order to optimize their use or design others that are more reliable.

The machines that man has created can direct production processes and other operations in accordance with programs established in advance, and sometimes they even automatically ensure the progress of processes to obtain the best possible result.

Finally ; machines can sometimes replace certain human organs such as arms (manipulator mechanisms, prostheses); etc.

Generally speaking, we can say that the machine is a device that man created to discover and take advantage of the laws of nature, to facilitate his physical and intellectual work and make it more productive; all this by substituting it ,partially or entirely to its effort or to an organ.

We can give a more concise definition: the machine is an object which produces mechanical movements aimed at transforming energy, matter and information.

Among other tools, the study of mechanisms whose objective is the analysis of the necessary movements of knowledge in mathematics and general mechanics and more particularly the basic notions of kinematics.

2. Kinematic connections between mechanical parts:

1. Notions on kinematic couples:

1.1 Definitions of a kinematic couple:

A kinematic couple is a mobile assembly of two elements in contact.

The elements can be brought together in kinematic couples in a multitude of ways. The following figure (8) shows; for example; a so-called rotation kinematic couple; in which the assembly of elements A and B is carried out by two cylinders located in permanent contact. The glues of the interior cylinder prevent the movement of one cylinder relative to the other along the axis xx but do not oppose the rotation of one cylinder relative to the other.

The second figure (9) shows the assembly world of the elements, which limits the relative movement of the two elements A and B. This kinematic couple allows relative rolling. sliding and rotation. Thus, the relative movement of each element of a kinematic couple is subject to certain restrictions which depend on the mode of assembly of the elements of the couple. These restrictions imposed on the kinematic couples will be called connection **conditions** .

Figure 1: Kinematic Rotation Torque

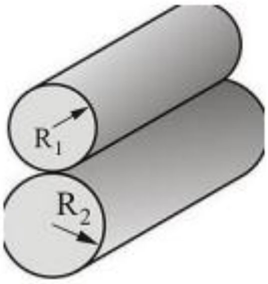


Figure 2: kinematic couple composed of two cylindrical surfaces in contact.

1.2 Kinematic connections:

A kinematic connection between two solids is characterized by the degrees of freedom that it allows.

A degree of freedom corresponds to the possibility of a rotational or translational movement between two solids.

A solid that has no bonds has six degrees of freedom.

- ✓ Three degrees of freedom in translation.
- ✓ Three rotational degrees of freedom.

To establish a kinematic diagram, we consider:

- ✓ That the surfaces in contact are geometrically exact and non-deformable.

- ✓ What movement is allowed is theoretically in play.

1.3 Number of degrees of freedom of a connection:

This is the number of independent translation and rotation movements that the connection allows. The number of force components transmitted by a link is equal to six minus the number of degrees of freedom of the link.

Example: 2-stroke micromotor

Overall drawing:

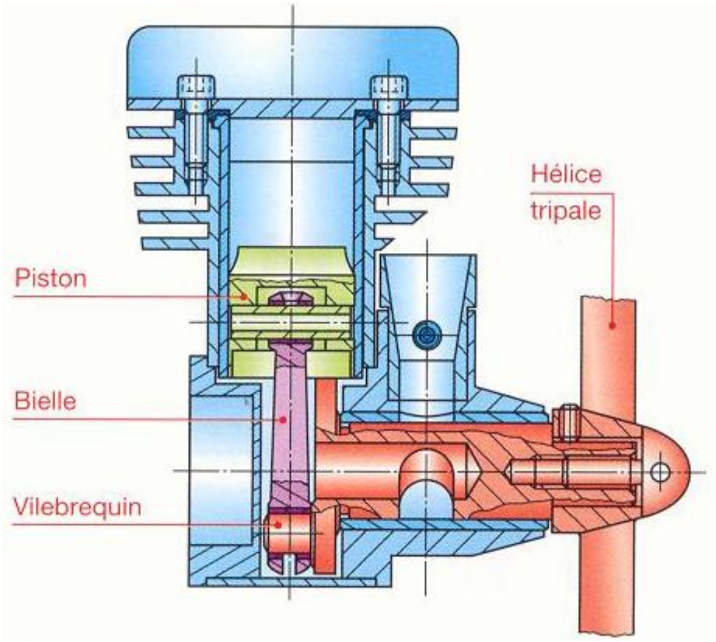


Figure 3: 2 -stroke micromotors

Kinematic Diagram:

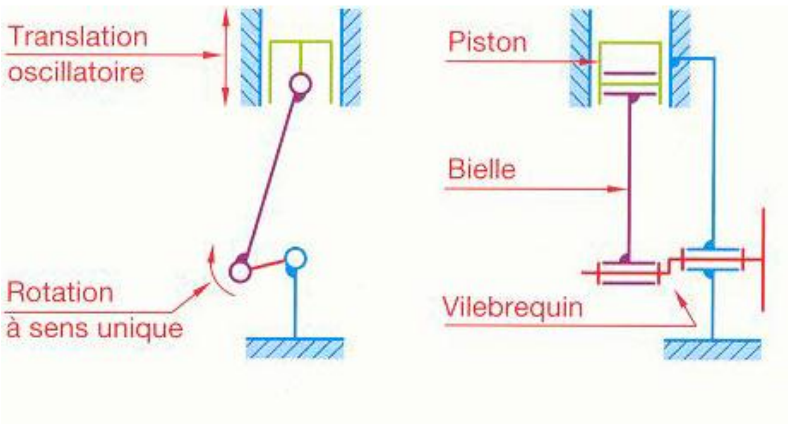


Figure 4: Kinematics diagram

Perfect connections: A connection is said to be perfect if the torso which represents the mechanical action of one of the solids on the other has as many components as there are degrees of freedom blocked by the connection.

Free connection:

It is a connection with 6 degrees of freedom, no effort transmitted. 'connection with 6 degrees of freedom. This "connection" is in fact an absence of connection the solid is left to itself "case of a satellite in space, or a ballistic projectile".

Point connection:

Two solids S_1 and S_2 are in point connection if during their relative movement a point A_2 of (S_2) remains in a plane P_1 of (S_1). Connection with 4 degrees of freedom.

Annular linear connection:

Two solids S_1 and S_2 are in an annular connection if, during their relative movement, a point A_2 of (S_2) remains on a line D_1 of (S_1). Connection with 4 degrees of freedom.

Ball joint connection:

Two solids S_1 and S_2 are in a ball joint if, during their relative movement, a point A_2 of (S_2) remains coincident with a point A_1 of (S_1). This is a 3 degree connection of freedom.

Plane support connection:

Two solids S_1 and S_2 are plane supports if, during their relative movement, a plane P_1 of (S_2) remains coincident with a plane P_1 of (S_1). This is a connection with degrees of freedom .

Ball joint to "finger" connection:

Two solids S_1 and S_2 are in a "ball joint to finger" connection if, during their relative movement, on the one hand a point A_2 of (S_2) remains coincident with a point A_1 of (S_1) and on the other hand a point B_2 linked to (S_2) remains in a plane P_1 linked to (S_1) and containing A_1, it is a connection with 2 degrees of freedom.

Sliding pivot connection (or lock):

Two solids S_1 and S_2 are in a sliding pivot connection if, during their relative movement, a straight line D_2 linked to (S_2) remains confused with a straight line D_1 linked to (S_1); it is a connection with 2 degrees of freedom.

Slide connection:

Two solids S_1 and S_2 are in sliding connection if, during their relative movement, on the one hand a plane P_2 of (S_2) remains coincident with a plane P_1 of (S_1) and on the other hand a straight line D_2 linked to (S_2) and located on the plane P_2 remains confused with a straight line D_1 linked to (S_1) and located in the plane $P_{1.}$ It is a connection with 1 degrees of freedom.

Pivot link:

Two solids S_1 and S_2 are in a pivot connection if during their relative movement, two points C_2 and D_2 of (S_2) separated by a length **L** remain coincident with two points C_1 and D_1 of (S_1) separated by the same length **L** not zero. It is a connection with 1 degrees of freedom.

Helical slide connection:

Two solids S_1 and S_2 are in a helical slide connection if, during their relative movement, on the one hand a straight line D_2 of (S_2) remains coincident with the axis D_1 of a circular helix H_1 With a radius linked to (S_1) and on the other hand, a point A_2 of (S_2) located at a distance r from D_2 describes the circular helix H_1. The relative movement of S_1 with respect to S_2 is broken down into a rotation around associated with a following translation. These two movements are not independent, but follow the law where x is the following displacement of S_1 with respect to S_2, **p** the pitch of the propeller, θ the angle of rotation of S_1 relative to $S_{2.}$ It is a connection with 1 degrees of freedom.

Built-in connection:

Two solids S_1 and S_2 are in an embedded connection if, during their relative movement, on the one hand a straight line D_2 of (S_2) remains coincident with a straight line D_1 of (S_1), and on the other hand apart from a point A_2 of (S_2) located at a non-zero distance d from D_2 remains coincident with a point A_1 of (S_1) located at a non-zero distance d from D_1. The embedding connection does not allow any relative movement between the two solids.

2. Application examples:

Robot with one degree of freedom in rotation and two degrees of freedom in translation:

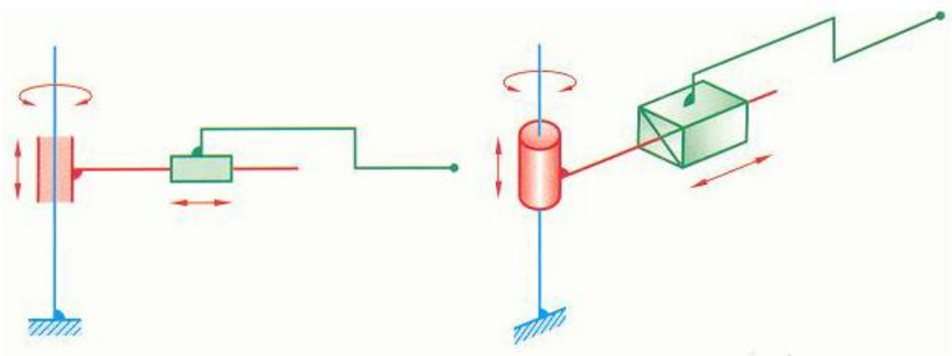


Figure 5: Robot has 2d.d. l in Rotation **Figure 6:** Robot at 2d.dl in Translation

Robot with three rotating degrees of freedom:

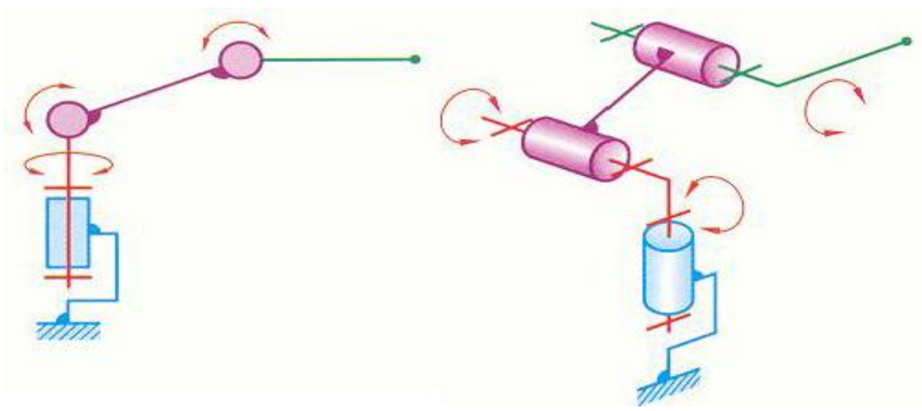


Figure 7: Robot with 3 dof in Rotation

3. Kinematic torque and degrees of freedom:

We can always represent the movement of such a body as rotation around three arbitrary reciprocally perpendicular axes X,Y,Z and sliding along these axes. So, in general cases, a solid body placed in space is free to perform six independent movements: Three rotations around the axes X, Y and Z and three translations along the same axes. It follows that if the movement of the first element of the kinematic couple **. (Figure 8).**

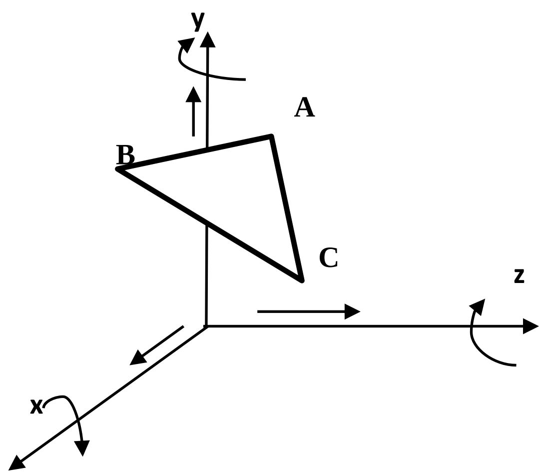


Figure 8: For determining the position of a body in space.

As has already been said previously, when one element constitutes a kinematic couple with another, the relative movements of these elements are subject to certain connection conditions. It is obvious that the number of these connection conditions must be entire and always less than six .car, already six link conditions.

Therefore, the number of connection conditions **C** imposed on the relative movement of each element of the kinematic couple can only vary from 1 to 5.

Such as :$\mathbf{1 \leq c \leq 5}$

When c=0, this indicates the elements a and b are free between them. When c=6, this expresses the impossibility of relative movement between the elements of the couple, that is to say a rigid connection (embedding).

The number of degrees of freedom **N** is an integer, it is between 1 and 5:

$$N=6-C.$$

The kinematic couples are expressed according to Malichev in classes, the class of a couple corresponds to the numbers of the connection conditions:

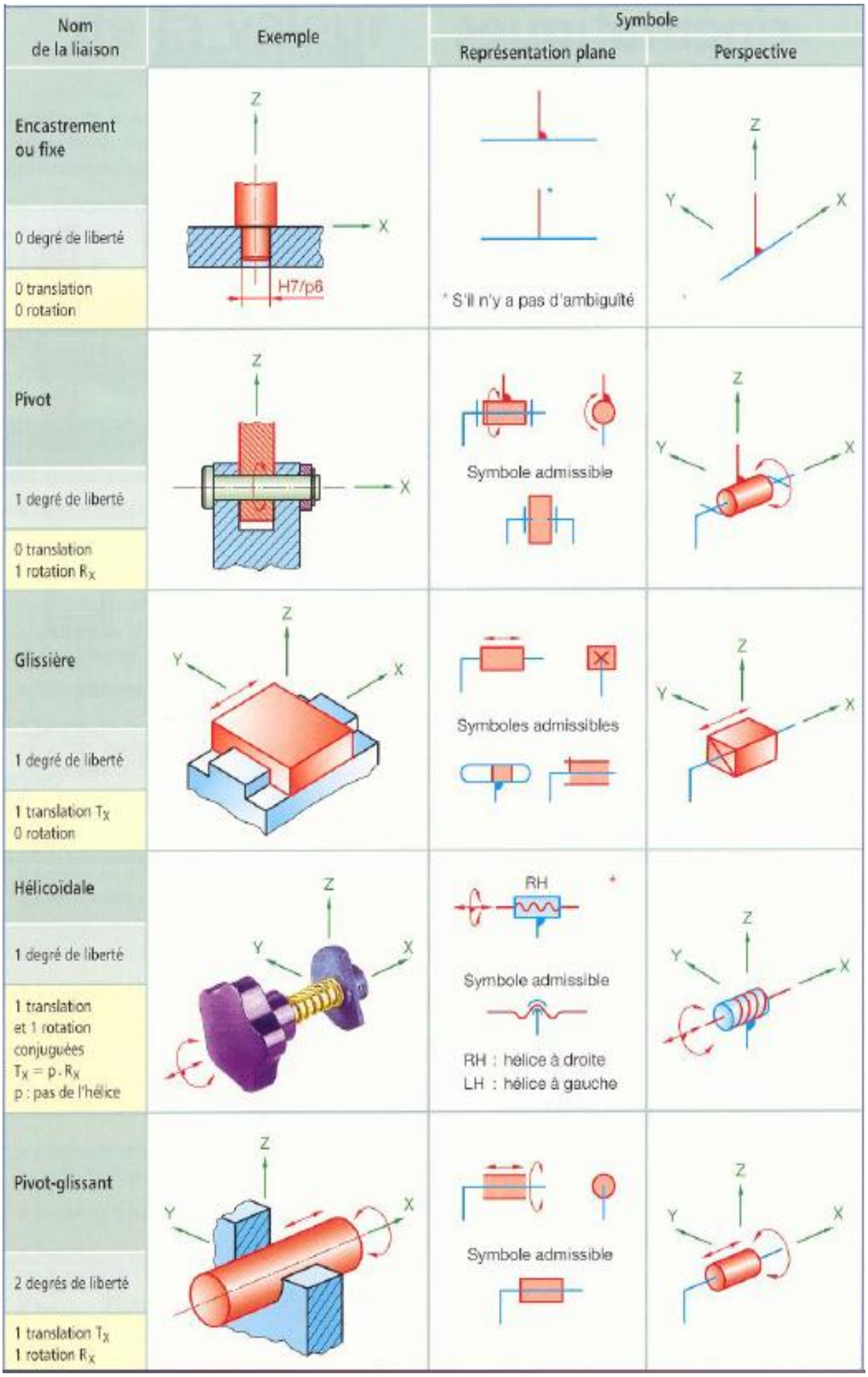
$$C=6-N$$

3.1 Example of kinematic couples and their classification:

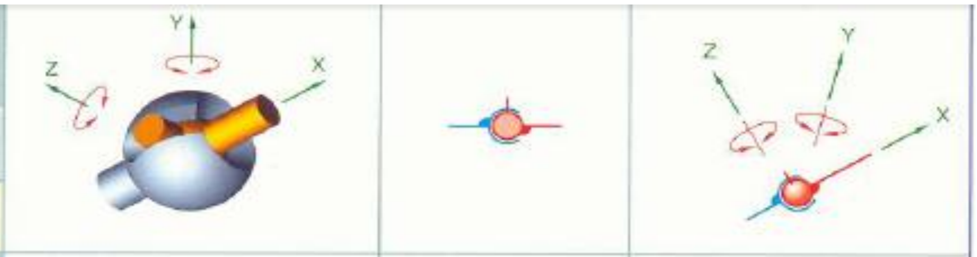
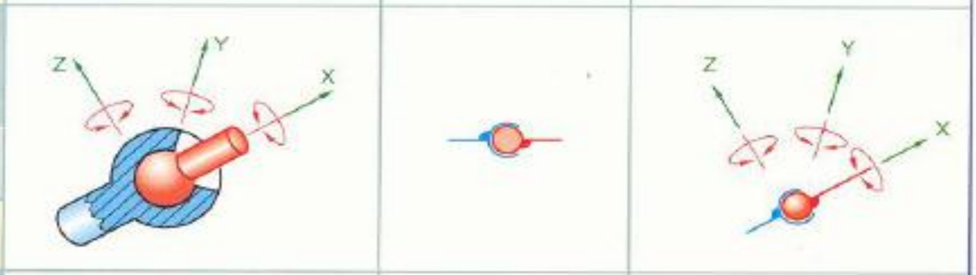
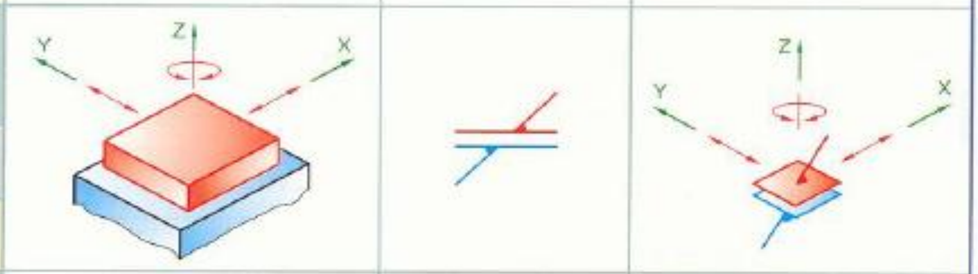
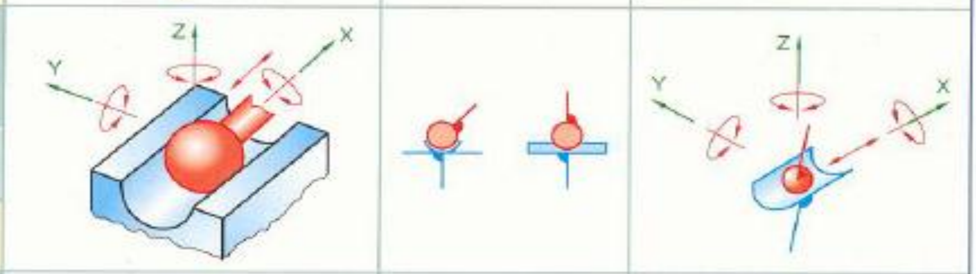
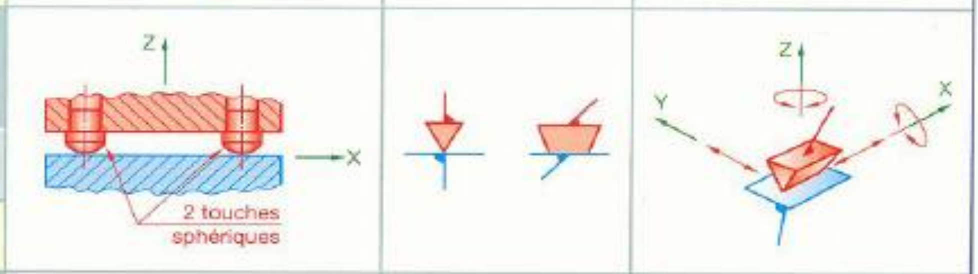
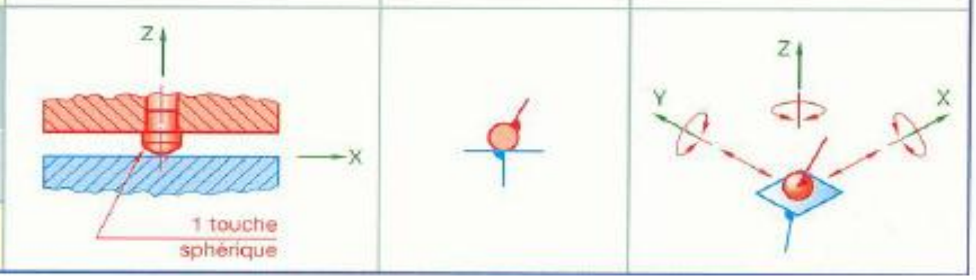
Therefore, according to this relationship, it results in five classes of kinematic couples that we represent in the following table:

Torque class	Removed Moves	Value of **N** degree of freedom	Possible movements	
			Translations	Rotations
1st Class –	1	5	2	2
2nd Class –	2	4	1 2	3 1
3 th Class	3	3	0 2	2 1
4 th Class	4	2	0 1	2 1
5 th Class	5	1	0 1	1 0

4. Usual connections of two solids:



Nom de la liaison	Exemple	Symbole – Représentation plane	Symbole – Perspective
Encastrement ou fixe 0 degré de liberté 0 translation 0 rotation	H7/p6	* S'il n'y a pas d'ambiguïté	
Pivot 1 degré de liberté 0 translation 1 rotation R_X		Symbole admissible	
Glissière 1 degré de liberté 1 translation T_X 0 rotation		Symboles admissibles	
Hélicoïdale 1 degré de liberté 1 translation et 1 rotation conjuguées $T_X = p \cdot R_X$ p : pas de l'hélice		RH Symbole admissible RH : hélice à droite LH : hélice à gauche	
Pivot-glissant 2 degrés de liberté 1 translation T_X 1 rotation R_X		Symbole admissible	

Spérique à doigt 2 degrés de liberté 0 translation 2 rotations R_Y, R_Z	
Rotule ou sphérique 3 degrés de liberté 0 translation 3 rotations R_X, R_Y, R_Z	
Appui-plan 3 degrés de liberté 2 translations T_X, T_Y 1 rotation R_Z	
Sphère-cylindre ou linéaire-annulaire 4 degrés de liberté 1 translation T_X 3 rotations R_X, R_Y, R_Z	
Rectiligne 4 degrés de liberté 2 translations T_X, T_Y 2 rotations R_X, R_Z	
Sphère-plan ou ponctuelle 5 degrés de liberté 2 translations T_X, T_Y 3 rotations R_X, R_Y, R_Z	

5. **Kinematic diagram**

The parts which are in contact and which have no possible relative movement will be grouped into a set called an equivalence class. From a kinematic point of view, we can then consider these parts as being one and the same solid. In an overall drawing, these equivalence classes will be identified by specific colors.

The kinematic diagram makes it possible to analyze a mechanism by clearly showing the mobilities between the different sub-assemblies which constitute it. Its development is carried out in two stages:

5.1 Connection graph:

❖ Steps required for drawing the connection graph:

- Look for equivalence classes or kinematically linked groups of the mechanism.
- Search for pairs of equivalence classes in contact and their mobilities between them.
- From their degrees of freedom, determine the corresponding connection.
- Once the search is completed, it is possible to draw the graph.

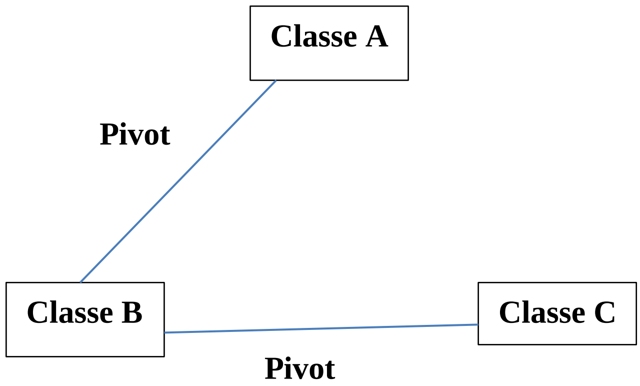


Figure 9: Connections graph

❖ Steps to draw the kinematic diagram (2D or 3D):

- Draw the absolute coordinate system.
- Place the points and axes of the connections.
- Draw the connections independently and in color.
- Connect the connections while respecting the axes of the kinematic assembly marks.

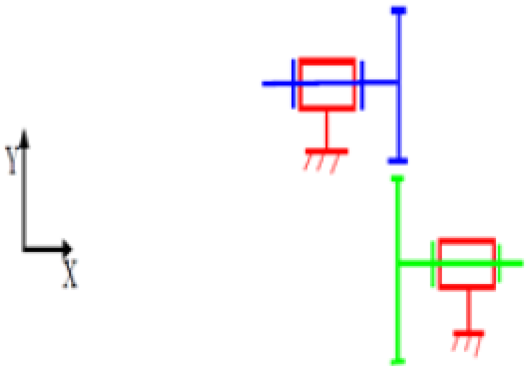


Figure 10: Kinematic diagram

5.2 <u>Example:</u>

In this example we are interested in the connection between a part and a clamp as indicated in the figure below:

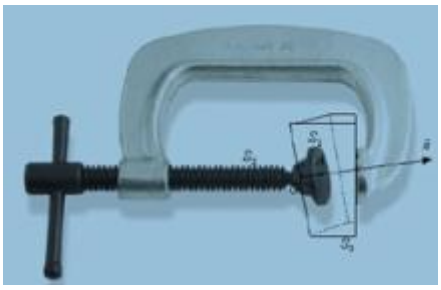
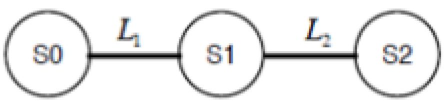


Figure 11: Clamp

Below is the connection graph and the kinematic diagram.



Graphe des liaisons

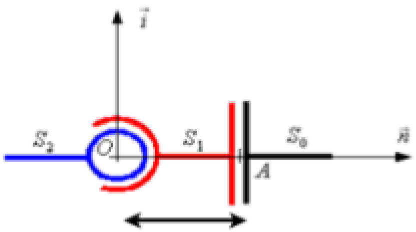


Schéma cinématique

Chapter 2: Creating connections

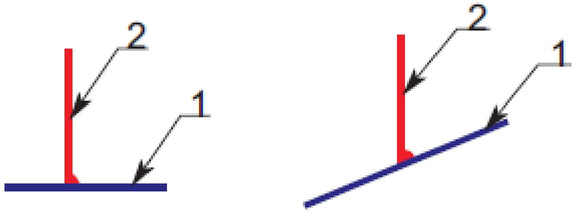
HAS . Dismantable assemblies:

The assemblies:

1.Definition:

The term assembly designates the constructive solutions which create a connection embedding **.**

An embedding connection is a complete connection which consists of immobilizing two (or more) parts relative to each other.



Planar representation Spatial representation

2. Functions provided by an assembly:

To create an embedding connection between two parts of a mechanism, the solution chosen construction must ensure the following functions in the "use" phase:

- position and hold the two pieces together in a stable manner;
- transmit mechanical actions;
- resist the surrounding environment.

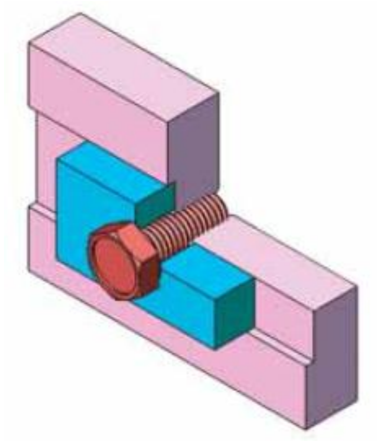
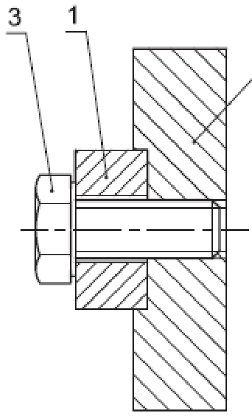
3.Quality indicators of an assembly:

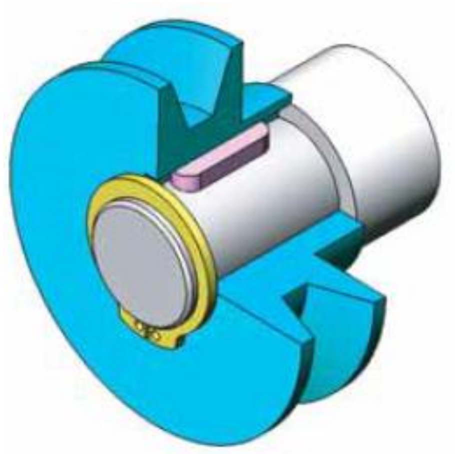
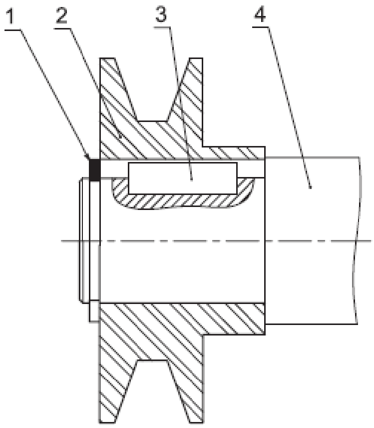
The choice of a constructive solution associated with an assembly is based on the following main indicators:

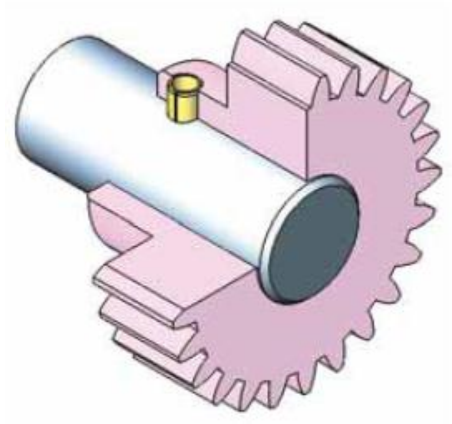
- degree of precision of positioning;
- intensity of transmissible mechanical actions;
- reliability.
- maintainability.
- congestion.
- aesthetic .
- cost.

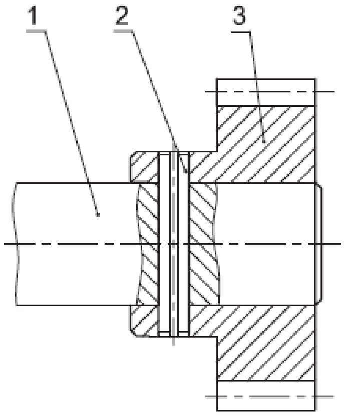
4- Examples of constructive solutions for an assembly:

4.1 Assembly by obstacles:

Example 1 : Assembly of parts (1) and (2)	
	
Positioning: Contact surfaces: Flat. **Maintained in position:** Screw (3).	

Example 2: Pulley (2) at the end of the shaft (4)	
	
Positioning: Contact surfaces: Cylindrical, flat (shoulder and key + groove); **Maintained in position** : Elastic ring.	
Example 3: Wheel (3) at the end of shaft (1)	

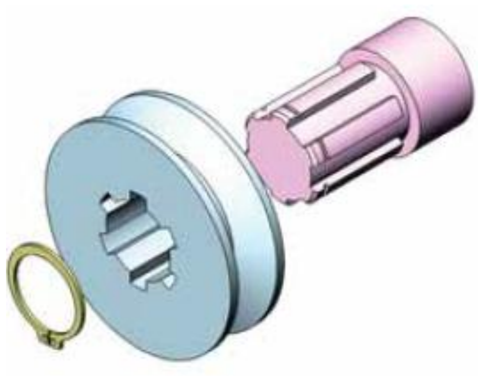


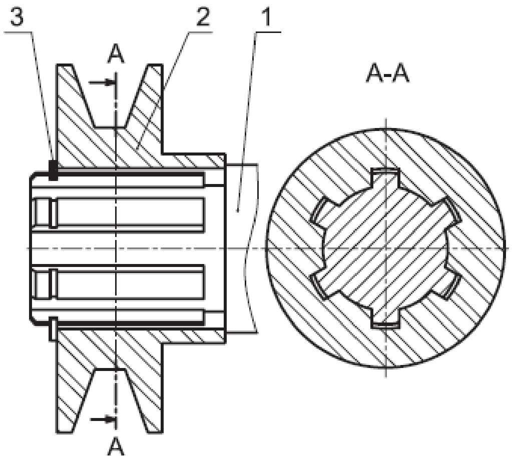


Positioning: Contact surfaces: Cylindrical.

Maintained in position : Elastic pin.

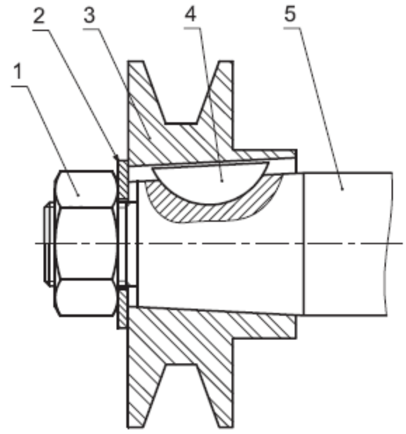
Example 4: Pulley (2) at the end of shaft (1)





Positioning: Contact surfaces: Cylindrical, flat (shoulder and grooves + grooves);

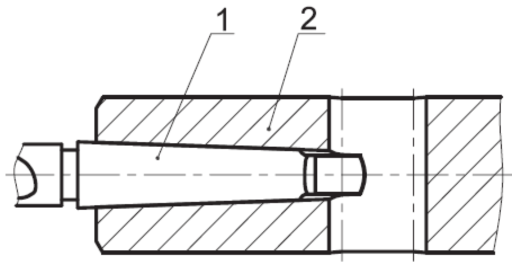
Hold in position : Elastic ring .

<table>
<tr><td colspan="2">Example 5 : Pulley (3) at the end of the shaft (5)</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td colspan="2">Positioning: Contact surfaces: conical, flat (key (4) + groove);

Maintained in position : Washer (2) and nut (1).</td></tr>
</table>

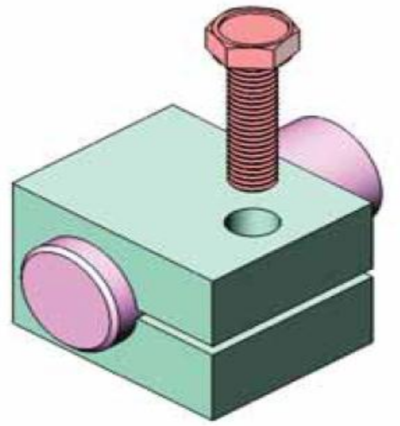
4-2 Adhesion assembly:

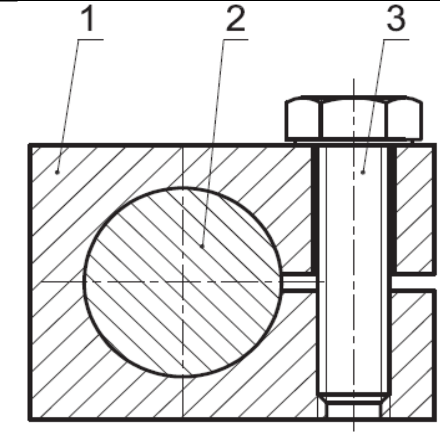
a- By jamming:

<table>
<tr><td colspan="2">Example: connection of the drilling bit (1) with the spindle (2)</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td colspan="2">Positioning: Contact surfaces: conical.
Maintaining position : grip.</td></tr>
</table>

b- By pinch:

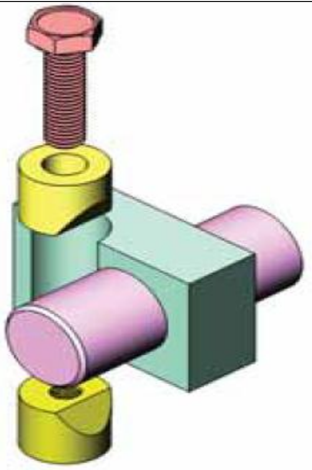
Example 1: Connection of axis (2) with part (1) (Deformation of part (1))
Example of use: - Fixing the table of a drill on the column;
- Fixing the comparator on the base...

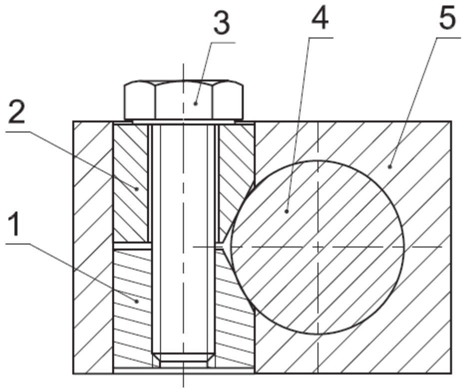




Positioning: Contact surfaces: cylindrical
Maintaining position : grip.

Example 2: connection of axis (4) with part (5)
Example of use: One-turn tailstock





Positioning: Contact surfaces: cylindrical
Maintaining position : grip

5. The reliability of removable assemblies:

Problem: When a screwed assembly is subjected to shock or vibration, there is a risk of loosening due to the play between the screw and the nut.

Reliability means ensuring that the position-holding element will not come loose.

B. Permanent Assemblies:

1. Welded assembly:

A welded assembly is continued by the permanent connection of several parts held together by one of the following processes:

Autogenous welding or welding:

The parts to be welded lose their original contours by fusion, by crushing or by diffusion. In the case of fusion welding, the connection is generally achieved through a filler material.

Brazing:

The pieces are assembled and retain their original contours.

The connection is obtained via a filler metal whose melting temperature T is lower than that of the parts to be welded. We distinguish :

- Strong soldering (T > 450°C).
- Welding - brazing (a > 450°Ctechnique similar to that of autogenous fusion welding).
- Soft soldering (T > 450°C).

Brazing does not generally provide the same mechanical strength and corrosion resistance as welding.

1.1 Representation of welds:

Whenever the scale of the drawing allows it, the weld must be and dimensioned (fig 1).

For discontinuous welds, the useful length of an element of the bead and the interval between the elements are rated.

The section of a discontinuous fillet weld is never hatched (fig 2).

If the scale of the drawing does not allow the welds to be drawn and dimensioned, a symbolic representation is used.

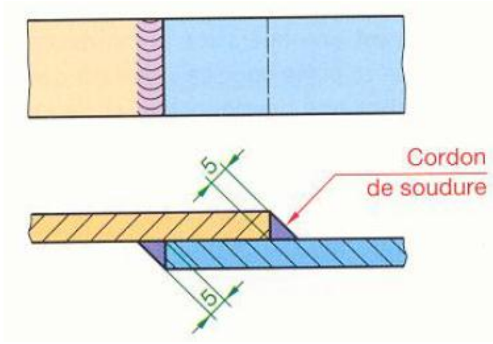


Figure 1: Continuous welding

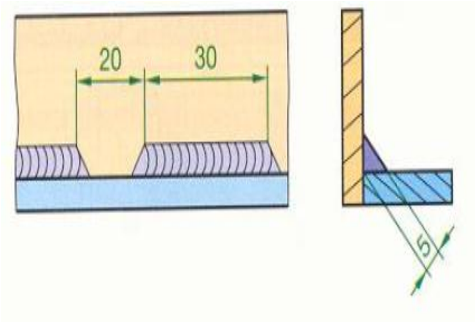


Figure 2: Discontinuous welding

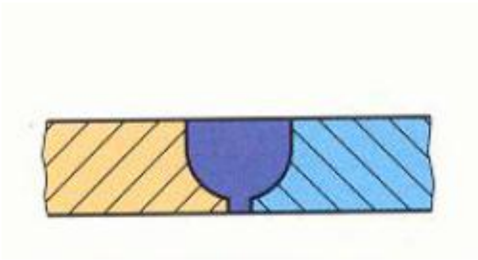


Figure 3: Simplified representations

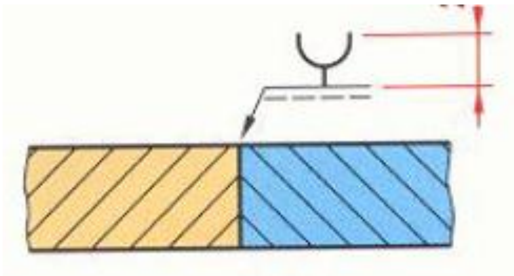


Figure 4: Symbolic representations

❖ **Symbolic Representations:**

The symbols indicate the shape of the weld produced, but they do not prejudge the welding process used. They must measure at least 2.5 millimeters in height.

At each weld joint, the symbolic representation must include:

- ✓ A guideline.
- ✓ A reference line.
- ✓ An identification line (except symmetrical welds).

If necessary, we can add:

- ✓ An additional symbolism.
- ✓ A conventional rating.
- ✓ Additional information.

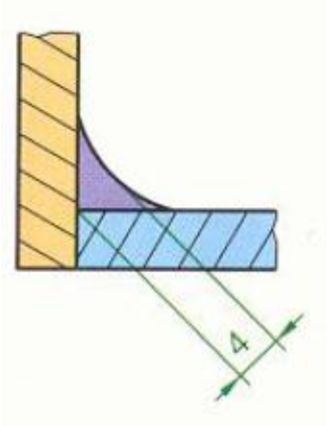


Figure 5: Simplified representations

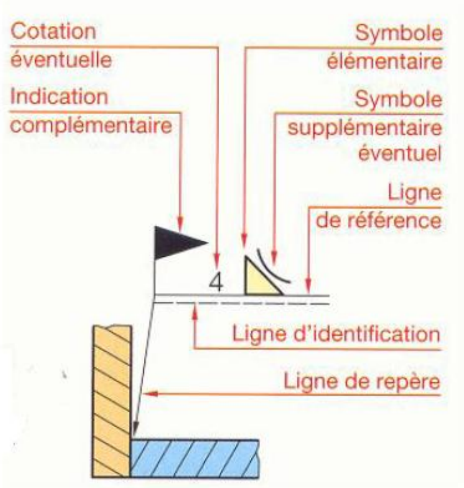
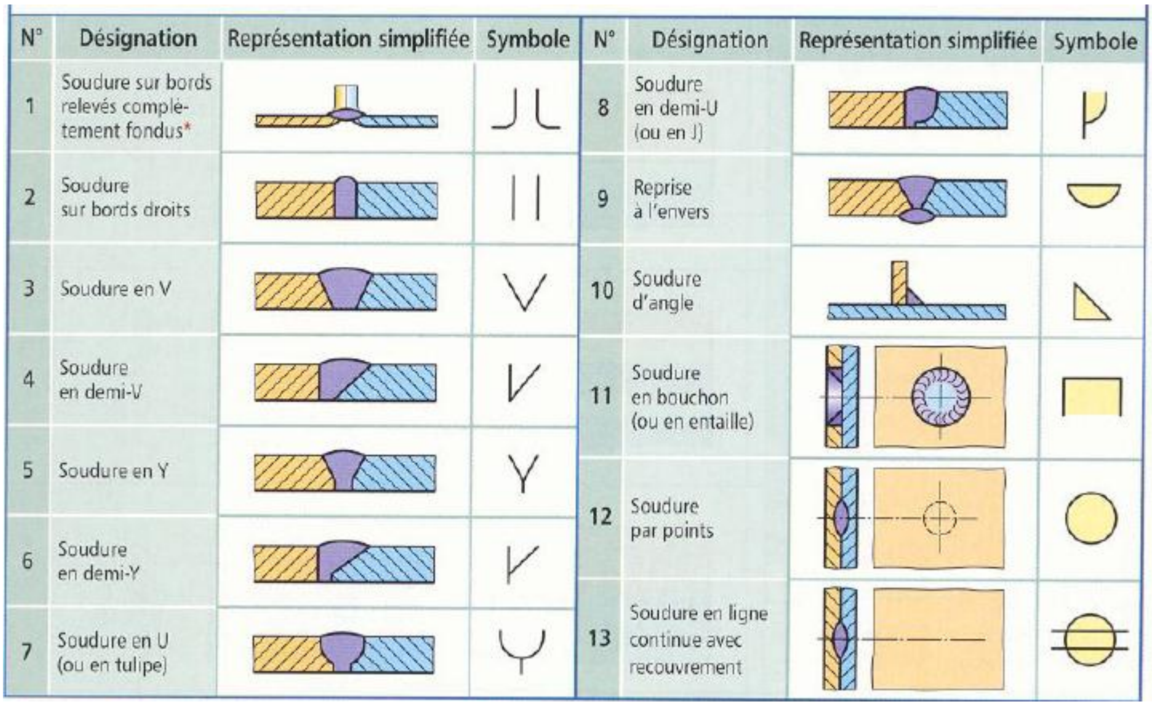


Figure 6: Symbolic Representations

1.2 <u>Welded joint types:</u>



N°	Désignation	Représentation simplifiée	Symbole	N°	Désignation	Représentation simplifiée	Symbole
1	Soudure sur bords relevés complètement fondus*			8	Soudure en demi-U (ou en J)		
2	Soudure sur bords droits			9	Reprise à l'envers		
3	Soudure en V			10	Soudure d'angle		
4	Soudure en demi-V			11	Soudure en bouchon (ou en entaille)		
5	Soudure en Y			12	Soudure par points		
6	Soudure en demi-Y						
7	Soudure en U (ou en tulipe)			13	Soudure en ligne continue avec recouvrement		

2. <u>Riveted assemblies:</u>

Riveted assemblies make it possible to economically obtain a non-removable embedding connection of a set of parts by displacement or by expansion of material of a malleable element (aluminum, aluminum alloys, copper, brass, mild steels, stainless steels, alloys of zinc…).

We essentially distinguish between riveting with or without an attached rivet; crimping and plate-making.

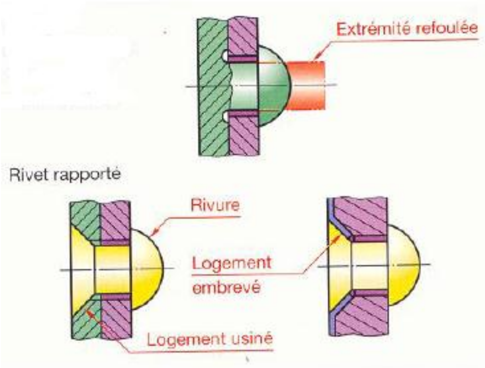


Figure 7: Type of riveting: Rivet coming in mass

3. **<u>Glued assembly:</u>**

   Glued assemblies create an interlocking connection between a set of parts using the adhesion qualities of certain synthetic materials.

   Interest in collage:

   - ✓ Conservation of material characteristics.
   - ✓ Possible assemblies of very different materials.
   - ✓ Waterproofing and anti-corrosion of the connection.
   - ✓ Elimination of galvanic couples between different metals.
   - ✓ Fast process for a large number of collages.
   - ✓ Good appearance of the pieces.

Bonding requires surface preparation depending on the materials to be assembled (mechanical or chemical stripping, degreasing, etc.).

Some materials require the application of a primer to improve adhesion.

Figure 8: Gluing a mobile phone speaker.