Preliminary and Reminders

I.1 Concept of the twist and its characteristics

A **twist** is a mathematical tool used mainly in the mechanics of the undeformable solid, to describe the movements of the solids and the mechanical actions to which it is subjected from an external environment.

Definition

A twist is a field of equiprojective vectors, the vectors of which $\overrightarrow{\mathcal{M}_P}$ at each point P are called "moments" of the twist. By the properties of such a field, the moments at two points P and O verify the Varignon relation:

$$\overrightarrow{\mathcal{M}_P} = \overrightarrow{\mathcal{M}_O} + \overrightarrow{PO} \wedge \overrightarrow{\mathcal{R}}$$

Where the vector $\overrightarrow{\mathcal{R}}$ (uniquely associated with any equiprojective field), is called the result of the twist. A twist is therefore determined by two vectors, constituting its "reduction" at any point P in space, namely:

- The resultant $\overrightarrow{\mathcal{R}}$. This vector is unique and independent of the reduction point.
- The moment in P of the twist $\overrightarrow{\mathcal{M}_P}$.

The resultant is therefore a characteristic vector of the field which makes it possible, from the moment at a particular point, to find the other moments. As a result, the twists form among the vector fields a sub-space of dimension 6 (in the case of the physical space of dimension 3).

We then write:

$$\mathcal{T} = \left\{ \begin{array}{c} \overrightarrow{\mathcal{R}} \\ \overrightarrow{\mathcal{M}_O} \end{array} \right\}_O$$

I.2 Definitions and assumptions

I.2.1 Definitions

I.2.1.1 Machine

Is a complex manufactured object capable of transforming one form of energy into another and using this transformation to produce a given effect, to act directly on the work object in order to modify it according to a fixed purpose.

Example: Steam machine is a machine that uses the transformation of water into saturated steam under the effect of a heat source to produce mechanical energy.

I.2.1.2 Mechanisms

In mechanics, a **mechanism** or (mechanical system) is a set of mechanical parts positioned together by contacts (and therefore in connections), forming a **coherent structure**, with the aim of performing one or more functions (movements). Some of which can move relative to others. This assembly therefore does not constitute a solid. Each of these independent movements, or kinematic modes, are called degrees of mobility.

In the general case, a mechanism is represented by:

- ✓ Its definition plan,
- ✓ its kinematic diagram or structure diagram if not minimum,
- ✓ Its links graph.

Example: the mechanism of a watch designates all the springs, balance or gears used to rotate the hands.

I.2.1.4 Fixed or built elements

The fixed parts constitute a rigid and stationary system, called a **frame**, these parts act as a support (base) for the other parts, see figure

I.2.1.5 Connection or Kinematic torque

A **connection** results from bringing two parts into contact via appropriate **functional surfaces. A connection is expected to transmit certain forces from one part to another, or to prevent certain movements of one part relative to the other.**

Two parts 1 and 2 are said to be connected or to form a kinematic torque if they are in permanent contact.

In order to carry out a proper study of the mechanism, it is essential, in addition to the notion of link, to understand the concept of the kinematic chain and the notion of mobility.

I.2.1.6 Planning mechanisms

A mechanism is called plane if the trajectories of all the points of the moving elements are in the same plane or in parallel planes.

I.2.1.7 Spherical mechanisms

A mechanism is called spherical when the points of the moving elements have trajectories located on concentric spheres.

Examples: 4-Bar Spherical Mechanism (Figure 1) and Cardan Joint (Figure 1)

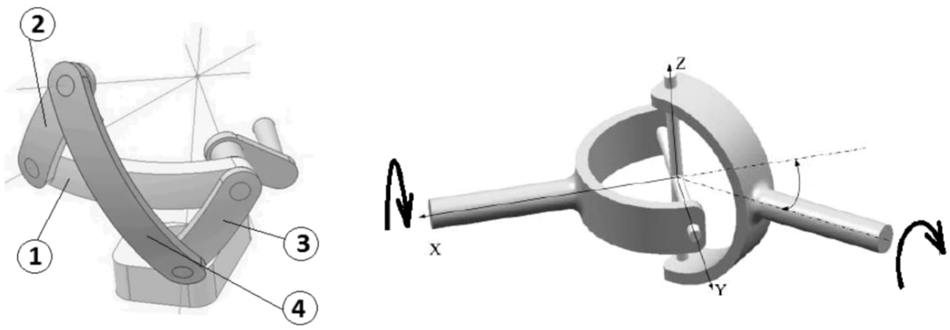

Fig.1 Spherical mechanism with 4 bars and Joint Cardan

1.2.1.8 Space mechanisms

A mechanism is called spatial (3D) if at least one element has points which have trajectories in space with the observation that the axes of the joints do not intersect.

Example: Four-link space mechanism

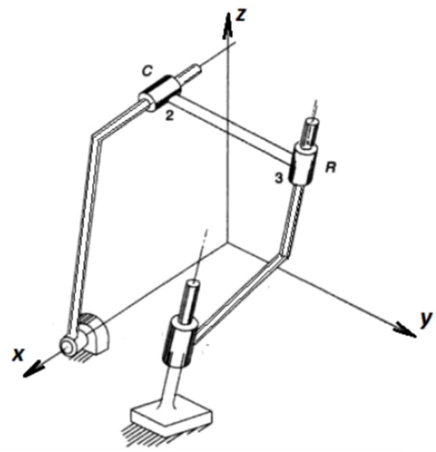

Fig.2 Space mechanism

I.2.2 Hypotheses and limitations of the study

The working hypotheses in mechanism theory are those of the kinematics of the solid:

- Parts modeled by undeformable solids.
- Perfect connections (without play, clamping, or friction) = > complementarity between the force twist and the kinematic twist.
- Connections with bilateral contact = > the contact is assumed to be maintained if the direction of the mechanical actions is reversed. (Case of point links, linear lines, plane support).
- Parts of zero mass (zero inertia forces).

I.3 Usual mechanical connections

I.3.1 Degrees of freedom of a rigid body

To properly perform the different technical functions of a mechanism, its constituents must be assembled in accordance with certain conditions which determine their possibilities of relative movement, i.e. their degrees of freedom (DDL).

A free room (in space) in all its movements is a room that has no connection with another room.

❖ *Locating a free rigid body in space*:

•Specify position + orientation

•By means of the position of 3 non-colinear points

•3 link relationships (fixed distance between points)

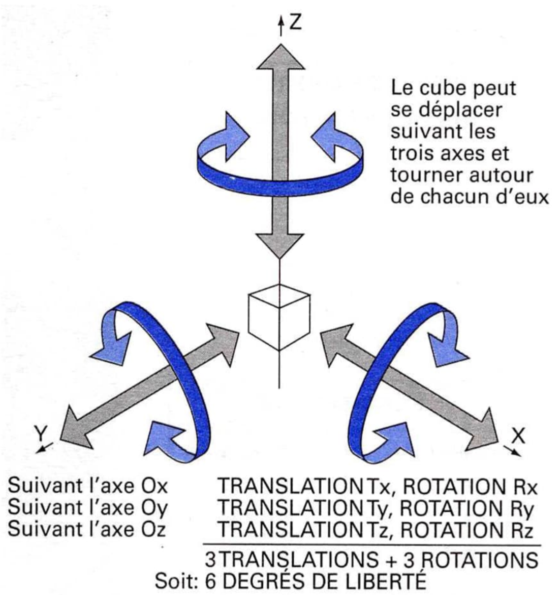

Fig.3 Degrees of freedom of a rigid body

All solid in space have 6 degrees of freedom, of which 3 translations along the axes (x, y, z) and 3 rotations along these same axes. Each of its movements takes place in both directions. This room has six degrees of freedom (DDL).

The lack of one of these 6 DDLs is a bond, so the relationship between the bonds **and the DDLs is** as follows: $N = 6 - L$;

Where - N: The number of DDL,

- L: The number of links

Functional mobilities of a mechanism: A mechanism is always modelable, from its model, the study can highlight

- The efforts involved is the field **of static**,
- The **relative movements** of its components is the domain of **kinematics**,
    - **The** transmitted powers are the domain of dynamics.