INNOVATIVE MECHANISM DESIGN WITH CAE SOFTWARE

Based on a work performed by **IFMA 2nd year students from MMS Department** (Machines, Mechanisms & Systems)

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The problem

Designing a mechanism for **moving two windshield wipers** with one electric motor (*Fig. 1*). **Creativity** : each pair of students must give a **unique** solution. Specifications of the mechanism are directly inspir++ed from previous research work.

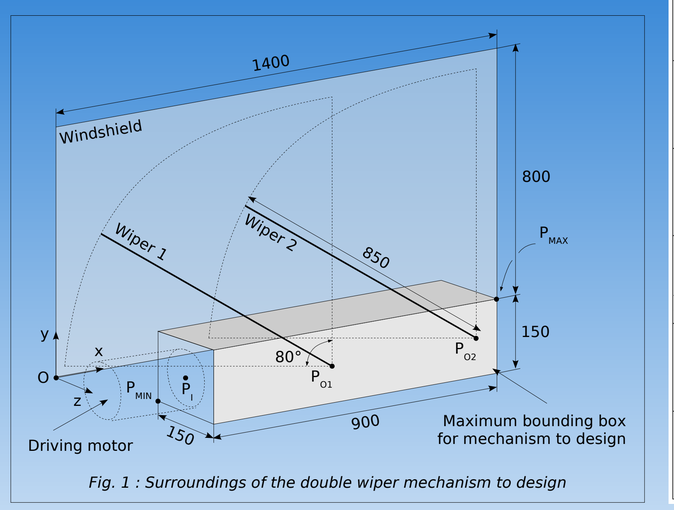


Fig. 1 : Surroundings of the double wiper mechanism to design

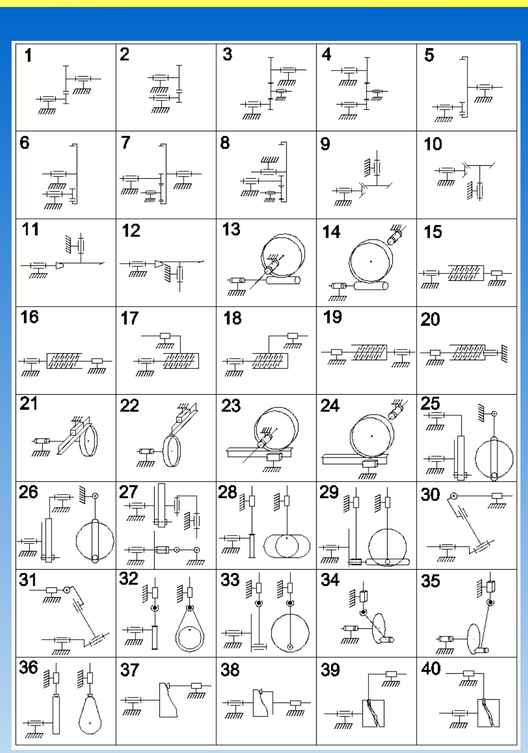


Fig. 2 : Forty basic mechanisms

The constraints

- The mechanism must be included in a maximum bounding box defined by two diagonal points P_{MIN} and P_{MAX} with :

  P_{MIN} = (500, -150, -150) and P_{MAX} = (1400, 0, 0)
- Input movement is a continuous rotation created by a DC electric motor connected on input point P_I = (500, -75, -75) with input axis parallel to x axis
- Output movements are alternate rotations around z axis located on output points P_{O1} = (850, -75, -0) and P_{O2} = (1350, -75, -0) Rotations start from vertical position on a range of 80°
- Transformation ratio: the electric motor runs at 1200 rpm for one wiping cycle frequency of 1 Hz, which means twenty rotations for one wiping cycle
- Efficiency must be over 70% when it is possible to calculate it

A few clues

A set of forty basic elementary stages coming from mechanism encyclopedias are provided, though the students are not limited to them (*Fig. 2*).

Student job

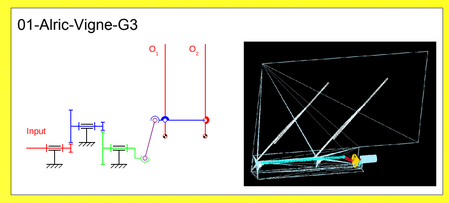
Each pair of student must :

- Find a solution that works (not necessarily the best)
- Create a virtual model of the mechanism with Adams software
- Analyze the mechanism behaviour from the engineer point of view

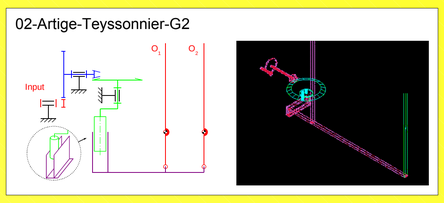
34 different solutions

are represented below among an extremely high number of possible solutions. Website : http://mms03.free.fr

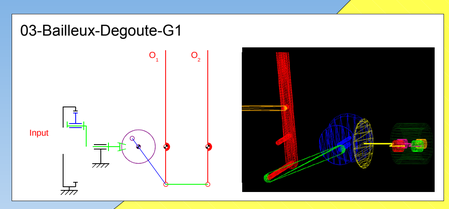
01-Alric-Vigne-G3



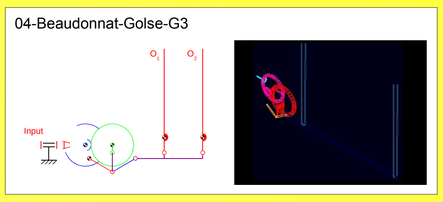
02-Artige-Teyssonnier-G2



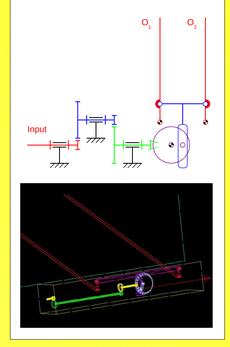
03-Bailleux-Degoute-G1



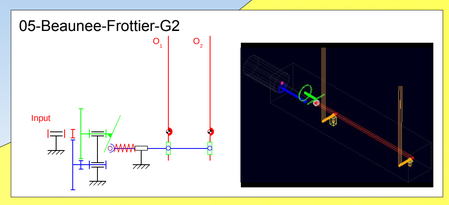
04-Beaudonnat-Golse-G3



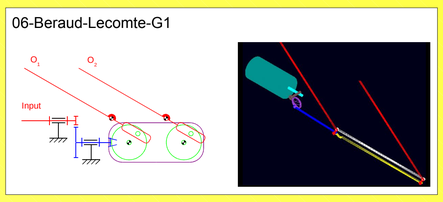
07-Besse-Genestier-G3



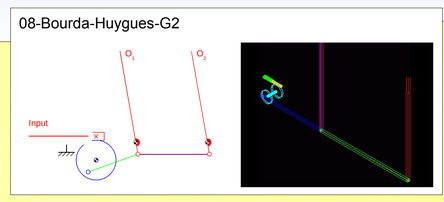
05-Beaunee-Frottier-G2



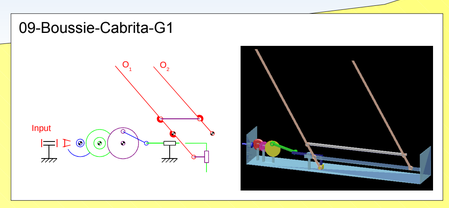
06-Beraud-Lecomte-G1



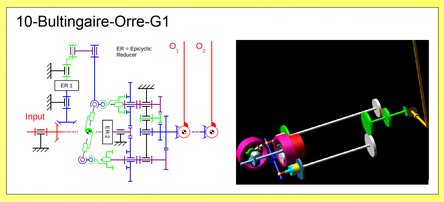
08-Bourda-Huygues-G2



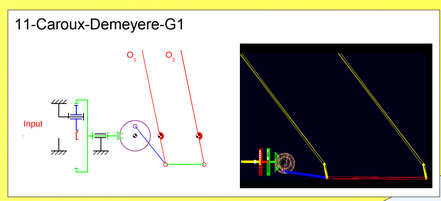
09-Boussie-Cabrita-G1



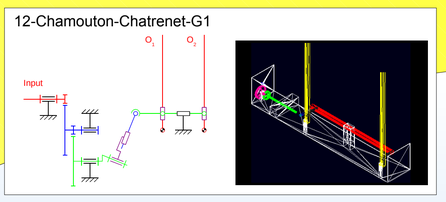
10-Bultingaire-Orre-G1



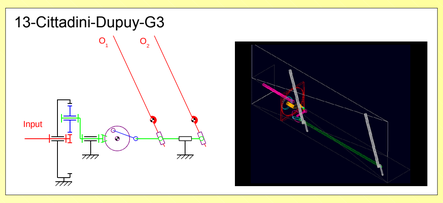
11-Caroux-Demeyere-G1



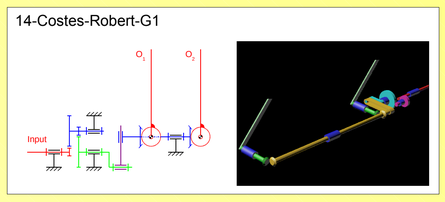
12-Chamouton-Chatrenet-G1



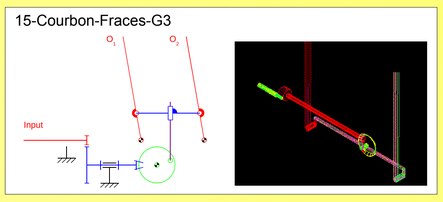
13-Cittadini-Dupuy-G3



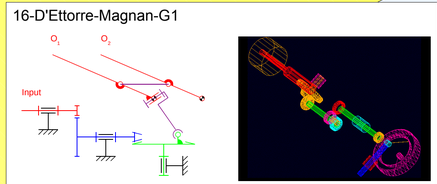
14-Costes-Robert-G1



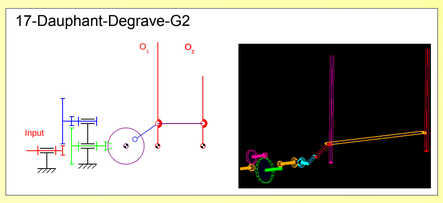
15-Courbon-Fraces-G3



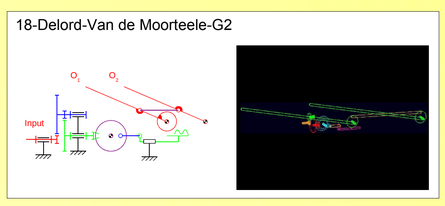
16-D'Ettorre-Magnan-G1



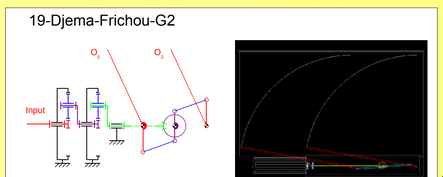
17-Dauphant-Degrave-G2



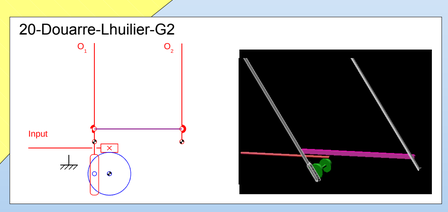
18-Delord-Van de Moorteele-G2



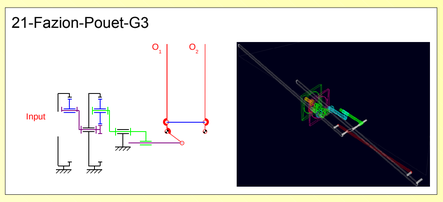
19-Djema-Frichou-G2



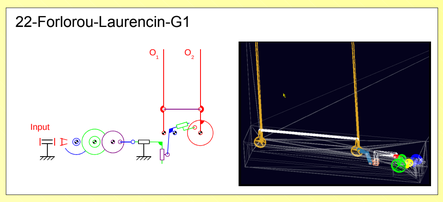
20-Douarre-Lhuilier-G2



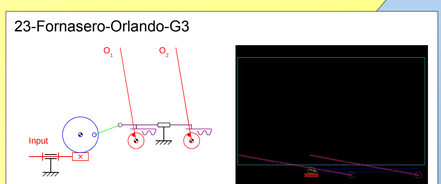
21-Fazion-Pouet-G3



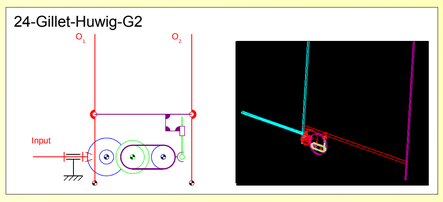
22-Forlorou-Laurencin-G1



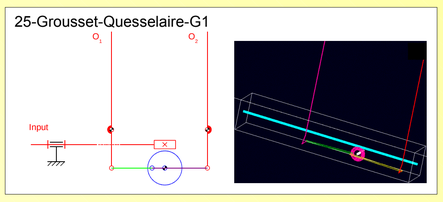
23-Fornasero-Orlando-G3



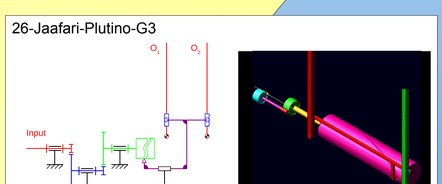
24-Gillet-Huwig-G2



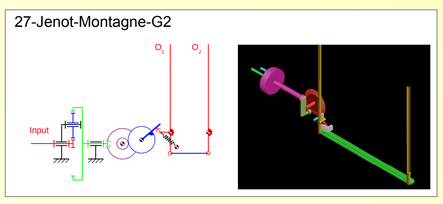
25-Grousset-Quesselaire-G1



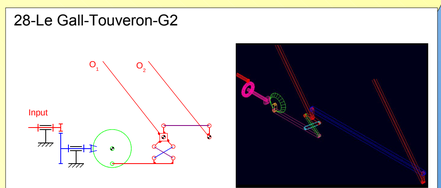
26-Jaafari-Plutino-G3



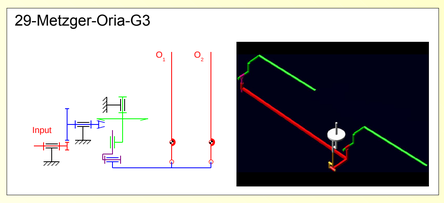
27-Jenot-Montagne-G2



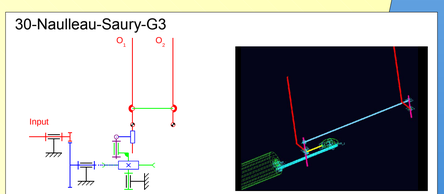
28-Le Gall-Touveron-G2



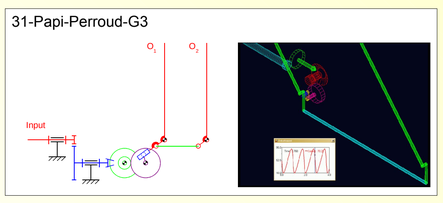
29-Metzger-Oria-G3



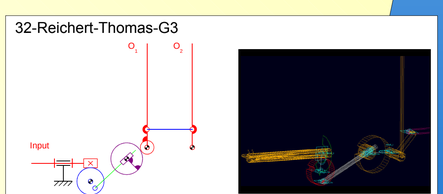
30-Naulleau-Saury-G3



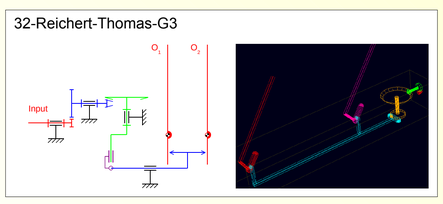
31-Papi-Perroud-G3



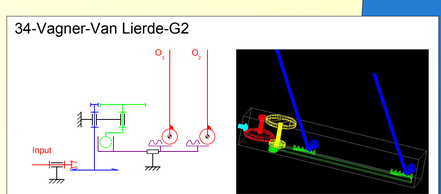
32-Reichert-Thomas-G3



32-Reichert-Thomas-G3



34-Vagner-Van Lierde-G2



Analysis of the solutions

We then try to find in this population of solutions some « natural tendencies » of young mechanical designers

Planar vs. Spatial

The majority of solutions use planar stages even though each stage can be in a different plane. Bevel / screw gear pairs are used to change the plane of motion. **Only four** proposed solutions (Sols. 1, 12, 16, 29) use **spatial chains** with one part in spatial movement.

Mechanism complexity

may be characterized by the **number of links**, **joints** and **stages** used for each solution. The simplest solutions (Sols. 8, 20, 25) uses only 8 joints while the most complex one (Sol. 10) uses 47 joints. Statistics are summarized in Table 1.

Tab. 1 :Statistics on mechanism complexity

Criteria	*Minimum*	*Maximum*	*Average*
Number of links	6	27	9
Numbers of joints	8	47	16
Number of stages	3	12	4

Classification by motion transformation between input and output

- **Continuous rotation – alternate rotation**: this family of mechanism uses exclusively revolute joints (such as Sols. 3 or 8)
- **Continuous rotation – alternate translation – alternate rotation**: this family of mechanisms uses alternate translation to generate alternate rotation at the output level (such as Sols. 5 or 13)

Mechanism bifurcation

How to generate an identical movement for the two wipers ?

- **Copying the movement of one wiper to the other**. There is a master and a slave wiper (such as in Sols. 1 or 3). Generally cheap but may introduce clearance and master wiper overload.
- **Symmetric transmission for both wipers**. Forces applied to each wiper are identical. Easy mechanical dimensioning but creates additional geometric constraints (such as in Sols. 7, 14 or 19)

Statistics on joints are summarized in *Fig. 3*.

- Revolute joints are the most employed. They appear 283 times in the 34 proposed solutions. However, only 8 of the mechanisms use exclusively revolute joints, regardless of gear contacts (Sols. 3, 5, 8, 11, 17, 19, 25 and 28)
- Gears are considered as “technological” joints as in Adams. They appear in the second position, with 99 occurrences, and they are commonly used for velocity reduction.
- Then come cylindrical and prismatic joints

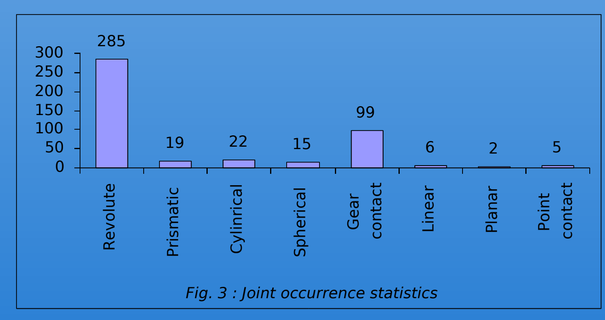


Fig. 3 : Joint occurrence statistics

Particular solutions

- Driving belt with uncommon use (Sol. 24)
- Chain interruption (Sol. 24)
- Chain commutation (Sol. 10)
- Unilateral contacts (Sols. 5, 10, 27,33)
- Bilateral contacts (Sols. 2, 26, 34)

Conclusion

- A creative work much appreciated by students
- Unicity constraints requires communication between groups
- The good approach to the solution : reduction / changing plane of motion / transformation continuous input to alternate output / bifurcation of output motion into 2 wipers
- Many comments on the way of thinking of the designer