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Development of a Didactic Concept and its Application for Contents in Mechanism Theory

Bachelorthesis

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Bachelorthesis

von **Paula García Revillo**

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Development of a Didactic Concept and its Application for Contents in Mechanism Theory

The use of digital media is a central point in everyday life is becoming more and more important.

Education is influenced in this way and especially education in the field of mechanism theory. A few decades ago the mechanism models were sketched on the lecture hall boards extensively or as a progressive step displayed with an overhead-projector. Nowadays these media are more or less banned from lecture halls and replaced by several interactive ones. In the field of mechanism theory interactive mechanism animations can be used to show the function of a mechanism, the stepwise presentation of a certain synthesis procedure improves the learning process effectively.

Regarding the internet, all these files can be offered on an interactive mechanism website, where the content of the lecture is provided with a scriptum character. Thus, the didactic concept is to be developed for. Especially the interactivity plays an important role to support a digital learning for the students. This website contains the entire content of the mechanism theory lectures. The synthesis and analysis procedures and the mechanisms must be implemented in the necessary stepwise way so that finally an online scriptum provided as website with interactive elements is generated.

This Thesis consists of the following work packages:

- Introduction to the topic
- Development of a Didactic Concept
- Implementation of the Contents
- Application of synthesis and analysis procedures
- Documentation and presentation of the thesis

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Die vorstehende Belehrung habe ich zur Kenntnis genommen:

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Paula García Revillo

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List of abbreviations

BWT	Bewegungtechnik; Motion technology
DMG	Digital Mechanism and Gear Library
EMAT	Elektromechanische Antriebstechnik; Electromechanical motion technology
IGM	Institut für Getriebetechnik und Maschinendynamik
RWTH	Rheinisch-Westfälische Technische Hochschule Aachen; RWTH Aachen University

1 Introduction

The use of digital media is a central point in everyday life. It is becoming more and more important, involving exchange of information and ideas, bibliographic search, or even a just more simple way to solve our day-to-day problems.

Education is influenced in this way. Today, worldwide scientific information at a medium-high level can be found outside universities and educational centres. This includes all kind of research studies, essays, books assembling applied theory and technique and even media files for a more didactic learning way.

Mechanism theory could not be an exception. A few decades ago the mechanism models were sketched on the lecture hall boards extensively or as a progressive step displayed with an overhead-projector. Nowadays these media are more or less banned from lecture halls and replaced by several interactive ones.

In the field of mechanism theory interactive mechanism animations can be used to show the function of a mechanism, the stepwise presentation of a certain synthesis procedure improves the learning process effectively.

Regarding the internet, all these files can be offered on an interactive mechanism website, where the content of the lecture is provided with a script character. Thus, the didactic concept is to be developed for. Especially the interactivity plays an important role to support a digital learning for the students. This website contains the entire content of the mechanism theory lectures. The synthesis and analysis procedures and the mechanisms must be implemented in the necessary stepwise way so that finally an online script provided as website with interactive elements is generated.

2 Background, motivation and goals

The RWTH Aachen University (Rheinisch-Westfälische Technische Hochschule Aachen) is a technical university well known in terms of engineering and especially in the field of mechanical engineering [1]. Therefore, as it should be, it tries to maintain this status, from a larger students' capacity, more and more complete facilities to a constant innovation in the matter of education, teaching and research.

Focusing on mechanical engineering, two subjects turn out to be outstanding: "Elektromechanische Antriebstechnik" (Electromechanical motion technology) and "Bewegungtechnik" (Motion technology), from now on called EMAT and BWT respectively. In particular, among this thesis, the main focus will be on BWT.

Currently these two subjects are taught through media content which the student can find via the online platform L^2P of the university, fact that results in a more comfortable and convenient way to find all the contents. This content can also be found in:

- A script [2] on which all required knowledge in order to pass both subjects is based,
- A collection of explanatory slides for the lecture and exercises sessions,
- A collection of homework exercises,
- Tasks which are supposed to be done in small groups,
- Different exams of previous courses,
- A formulary of the minimum content, and
- More information that can be interesting for the student who wants to study the subjects in depth (several links to other information websites, HiWi offers, and Bachelor and Master thesis opportunities).

As anyone can appreciate, all points of view of both subjects are included, from the learning material, to extra information and different ways to collaborate with the university. With the challenge of separating even more the didactic content from the institutional one, the IGM institute puts forward a project of carrying out a web page that collects all the necessary content for the learning of both subjects.

The goal of this project is to achieve the possibility that the student may learn in a more autonomous way as a complementary or additional manner to the traditional one. Concretely, the subjects related to mechanism theory are mastered once all concepts are internalised after being explained. From this website the fact that the student is the one who explains these concepts, using the different points of view of the same mechanical component, is expected. Thanks to an overall perspective of each element, its way of performance and its behaviour with other elements can be assimilated more efficiently. Thus, the student is witness of his own learning and then he is more interested in improving it. Furthermore, the digital media allows the interaction between student and content, which results in a closer and more complete approach the traditional theoretical subject.

The main motivation of this project is my own experience. On the one hand, all members working for this project already went through these subjects' learning process in their respective engineering degrees. On the other hand, they know the different stages of knowledge of mechanism theory, and also questions and misunderstandings which can show up among those stages and, especially, which tools or tips may help in order to achieve and comprehend the theoretical basics and proper functioning of the several mechanisms shown in the script. Therefore, working for the development of such a helpful tool for new students who are going to experience the same stages as oneself already did is always a huge source of motivation. First of all, solving mistakes or gaps that could exist previously, and secondly, providing educational improvements and updates to the learning system, so that mechanism theory progresses at the same rate as the environment of the students that are studying it. If a student may find an enormous quantity of information online, this information may also belong to his or her education, being a web portal which gathers all necessary topics for self-learning and understanding of all contents the most comfortable tool so far.

The final goal focuses on the compilation and creation of all necessary media files for achieving a full knowledge of both subjects mentioned above. These kind of files vary from the description of mechanical elements and its theoretical foundation to references to similar mechanisms or exercises within the range of the given subjects.

3 Approach

3.1 Evaluation of the files

The main goal of this project is to find an alternative and closer to the student way of teaching and explaining the concepts and mechanisms related to BWT. Currently, a countless quantity of different kind of files may be used, but an online portal collecting such a large amount of files is not desired, but the enough needed so as the student is able to learn in a more autonomous way and, at the same time, that all mechanisms keep the same pattern of display in a structured, organised way.

With the aim of achieving this range of approaches concerning a mechanism, different files are considered.

- Mechanism description
- Task
- Solution
- Step by Step solution
- Recipe
- Calculation
- Interactive files
- Interactive geometry software files
- Video
- DMG links
- Auxiliary sheet
- Further tasks files

3.1.1 Mechanism description

Its purpose is to offer at the beginning of each mechanism, a quick and simple look of the main characteristics of each one, setting up an initial base in order to keep going into detail about the mechanical knowledge of aforementioned mechanism. This initial information contains an explanation of the mechanism's location in the general listing (input and output movement, trace…) and also a summary of its basic mechanical characteristics which are supposed to be already understood by the student in previous courses (degree of freedom, movement relations…).

The information needed for carrying out the mechanism description is gathered from different sources. The own script offers along its introductory texts of each mechanism an overview of its basic functioning. Also, the DMG library offers descriptions of numerous elements shown in the script displayed in tables. So, the use of informative tables beside a descriptive image is considered to be the most visual way to obtain a brief introduction to each element.

3.1.2 Task

Once the mechanical element that is going to be studied is introduced, it is advantageous to have an image showing the starting point, even if it is a theoretical explanation or a physical element before operating. Therewith improvements in the learning at the beginning as well as at the end of each explanation may be obtained. On the one hand, the student can locate himself in the to-solve problem so as to clarify which the initial conditions are, therefore, the general approach of the mechanism description is transformed into a more precise point of view of what is going to be accomplished. On the other hand, regarding further stages of the learning, this file can be used as a proof element, from which the student can test himself and try to solve the task with neither auxiliary notes nor solutions.

3.1.3 Solution

All task should bring a solution along. As well as the task, the solution has also a double function. At first, it indicates the student the final state of the task. Thus, the cognitive capacity of the student is stimulated, and if the student has already a previous theoretical base, may start thinking of building up a possible way from the task to the solution. As a second function, it offers the student a check of the consolidated knowledge throughout the subject. Starting from the task, the student may try to solve the problem and verify via this solution file if the student has achieved the correct solution, and even more important, if it has been done using the proper methodology.

3.1.4 Step by step solution

A huge progress concerning the teaching of mechanism theory by using books or the script is the use of these files. So as to being able to show a step by step solution in a textbook, numerous and very similar images would be needed, in addition to the fact that the quality would not be comparable to the one in media files as usually these books are printed in black and white editions or without an adequate definition; fact that would hinder a clear, concrete and differentiated vision of the following steps which have to be carried out among the task. A sequence of differentiated steps leads the student progressively form the task to the solution avoiding the necessity of a different image for each step. Keeping a pattern with the other mechanisms, for example, showing the main axes always in the same format, displaying each step in a different colour of even highlighting each step individually while the previous steps stay in background can be different tips in order to show through a single click the progress achieved by each step.

3.1.5 Recipe

This file is closely related to the previous one (“Step by step solution” file), as it brings the same content: a sequence of steps from the “Task” to the “Solution” file. However, its function is not explanatory, but focused on the assimilation and remind of that content. “Step by step solution” files show what is obtained after each step while the recipe’s goal is a summary of these steps, in other words, the order in which these steps should be performed, the order which

the student has to keep in mind so as to get to the solution. The use of this tool is supported by own experience, as all members of this project know that even if the understanding of the way from the "Task" to the "Solution" is learned, sometimes it is necessary to memorize or internalize the sequence, especially before facing an exam.

3.1.6 Calculation

These files provide the theoretical basis for each mechanism, covering for each one the theoretical information which is more adequate for its comprehension. On the one hand, the equations or basic laws so as to follow the mechanical progress from the "Task" to the "Solution". Moreover, if the task concerns the demonstration of a theorem, its different steps, considerations, substitution and development of the different equations that lead to the already stated demonstration. On the other hand, these files can support the student's comprehension showing the meaning of each variable of the used equations, or, if the "Task" concerns a general mechanism, the "Calculation" file may provide a theoretical classification of the mechanisms that are inside the described general one. These files can be shown as they would be shown in a textbook, but also in a step by step format, that would result advantageous in cases of theorems' demonstrations or substitutions in several general formulas in order to achieve the solution of each task.

3.1.7 Interactive files

Mechanism theory taught in BWT focuses on the movement description of different mechanisms. Therefore, the existence of files that show the behaviour of each element is essential. That is the reason why "Interactive" files exist. These files are compound of a schematic picture (usually the same picture used in the "Task" and "Mechanism description" files, or at least a similar one) that has an interactive layer on it. This layer may be activated by the student and then, the student can move it so as to see the reaction of the mechanical element. It results in a fundamental learning tool, as the student is able to watch the picture on which the theoretical principles already learnt are based and, simultaneously, the movement the mechanism makes.

3.1.8 Interactive geometry sofware files

As a complement to the "Interactive" files, are the ones generated by geometry softwares as GeoGebra or Cinderella. These files are labelled as complementary to the previous ones as they bring advantages and disadvantages. On the one hand, these files do not show a schematic image which explains the functioning of the element at the previous files as the "Task" or the "Mechanism description"; fact that is accomplished by the "Interactive" files. However, they bring the possibility of modifying the parameters that define the mechanism (links' length, velocities, angles, among others). This characteristic is ideal not only to see how a mechanism operates, but also to develop the mechanical capacity of the student, being able to see how the movement is altered by changing certain parameters of the studied mechanism.

3.1.9 Video

By both interactive files the student can move and modify as the student wants the mechanism, fact that leaves a gap concerning the regular behaviour of the element with no alteration. This triggers the convenience of adding a video file in which the student can appreciate how the mechanism operates under standard conditions of work, velocity and measures.

3.1.10 DMG links

Considering that this information website contains a large amount of files (such as descriptions, interactive files, videos, text material…) adding an internet link in which the student is able to find all and further information about that mechanism becomes truly useful. This project gathers the required information concerning the subjects EMAT and BWT, so this link may bring a deeper content in case that the student wants to learn more about certain elements or simply access to the original files provided at the online script (videos, interactive files…).

3.1.11 Auxiliary sheet

Both subjects (EMAT and BWT) offer as learning material a document that collects the main formula, mechanical laws and descriptions of the basic elements studied during the subjects. This document may be used as an auxiliary sheet during the learning stages but also during the examination of both subjects, so it is of a great usefulness that the online script indicates whether the mechanism that is being learned appears in this auxiliary document or not, and which information is shown on the document.

3.1.12 Further tasks

As it happens in every engineering field, the knowledge and command of a subject is achieved by the repetition of exercises and the fulfilment of similar tasks which can be solved with the mechanical level achieved along the subject. Then, and as it is in all learning method, a collection of further tasks related to the previously learned is indispensable. This results in a file compiling further tasks focusing on what has been learnt with all the files from the script, which is basic to complete and consolidate the whole knowledge required in the subject.

3.2 Collection of information

In order to carry out this project, several stages have to be fulfilled, even though throughout its duration those stages its results must be corrected, specified and adjusted, since the deeper the information of a mechanism is, the more is known about which elements and files are useful for its explanation

1. Introduction to the script and distribution of its content.
2. Allocation of the documentation from the script.

3. Collection of content.
   3.1. Content provided by lecture material from both subjects.
   3.2. Content provided by the Mechanism-Model-Collection (IGM institute).
   3.3. Content provided by L^2P platform.
   3.4. Content provided by DMG library.

3.2.1 Introduction to the script and distribution of ints content

As a previous phase to the beginning of the project, a first overlook of the script "Vorlesungsumdruck: Mechanismentechnik" is carried out. Due to the fact that it summers two different subjects, the task is done by two different people. One of them focuses on the content belonging to EMAT mainly, while the other one is in charge of the content related to BWT. Each one selects the images which are considered more explanatory and relevant for collecting mechanical information and also which are the subject of study along both subjects. The final outcome of this phase is an Excel sheet indicating the distribution of topics.

3.2.2 Allocation of the documentation from the script

This phase is basically in charge of digging deeply in the previously selected images with the aim of finding as much information as possible from the script. Essentially information required to create calculation (formulas, mechanical laws, theoretical developments) and description files is found.

3.2.3 External sources of content

3.2.3.1 Content provided by Lecture sessions material from both subjects

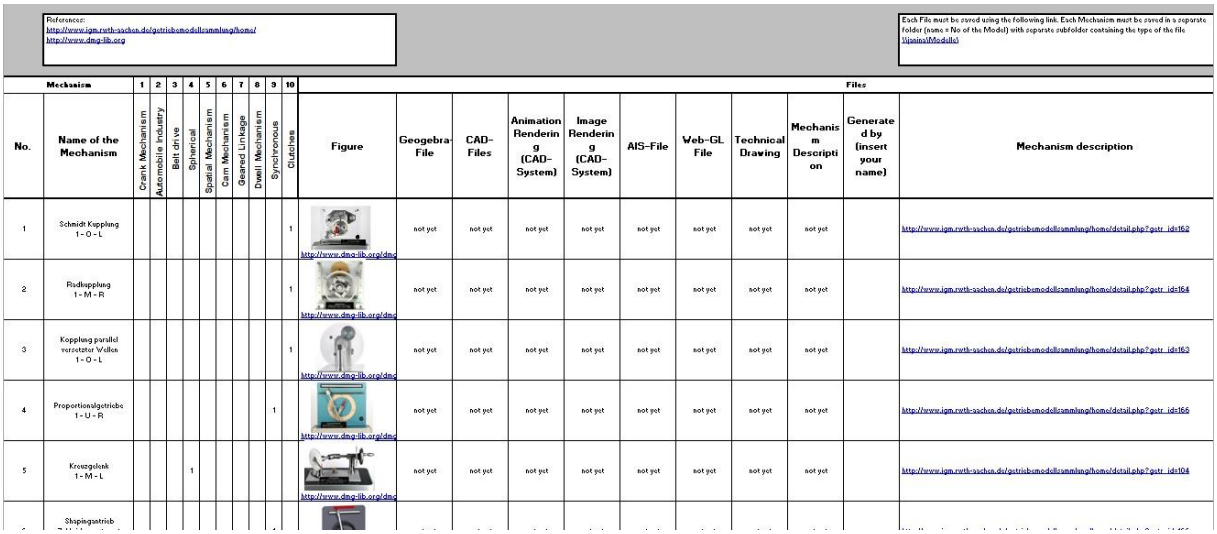
One of the main sources of already created files and content for the realisation of this project is the collection of slides which are currently used in the lecture sessions of both subjects. Therefore, the main resource are the original power point presentation, which are a fundamental source of content related to "Step by step solution" files. Moreover, as these slides are the original ones, its edition is allowed so a separation from the lecture structure is possible and then the new files focus just on the explanation of the element itself. This slides also complement the script when creating "Calculation" files as they already supply a more brief and concise representation of the formulas from the script and a possible display of them.

In addition, along with the collection of slides, several "Interactive geometry software" files from softwares as GeoGebra or Cinderella are provided, as they are linked at the slides. These files are the main source of interactive geometry software files for this project.

3.2.3.2 Content provided by the Mechanism-Model-Collection (IGM institute)

At the beginning of this project, besides the script, an Excel sheet (see **Fig. 3.1**) is provided by the IGM institute, in which all mechanisms that are studied in this institute are collected. These mechanisms are classified in different categories (Crank mechanism, Automotive industry, Belt

drive, Spherical, Spatial mechanism, Cam mechanism, Geared linkage, Dwell mechanism, Synchronous and Clutches) and also a link to the IGM library [3] is provided. This links lead to the files (CAD, GeoGebra, description files) that have been already created at the institute. This library is a main source for interactive geometry software files, descriptions and videos.



	Mechanism	1	2	3	4	5	6	7	8	9	10	Files									
No.	Name of the Mechanism	Crank Mechanism	Automobile Industry	Belt drive	Spherical	Spatial Mechanism	Cam Mechanism	Geared Linkage	Dwell Mechanism	Synchronous	Clutches	Figure	Geogebra-File	CAD-Files	Animation Rendering (CAD-System)	Image Rendering (CAD-System)	AIS-File	Web-GL File	Technical Drawing	Mechanism Description	Generated by (insert your name)	Mechanism description
1	Schmidt Kupplung 1 - O - L										1		not yet	not yet	not yet	not yet	not yet	not yet	not yet	not yet		
2	Radkupplung 1 - M - R										1		not yet	not yet	not yet	not yet	not yet	not yet	not yet	not yet		
3	Kopplung parallel versetzter Wellen 1 - O - L										1		not yet	not yet	not yet	not yet	not yet	not yet	not yet	not yet		
4	Proportionalgetriebe 1 - U - R									1			not yet	not yet	not yet	not yet	not yet	not yet	not yet	not yet		
5	Kreuzgelenk 1 - M - L				1								not yet	not yet	not yet	not yet	not yet	not yet	not yet	not yet		
6	Shapingantrieb									1												

Fig. 3.1: Mechanism-Model-Collection

3.2.3.3 Content provided by L^{2}P platform

Both BWT and EMAT offer all their content at the L^{2}P platform of the RWTH (see **Fig. 3.2**). This platform facilitates the exchange of information concerning both subjects between professor and students, since evaluation criteria, schedule and location of tutorial meetings, contact email, and learning material as the collection of slides mentioned before, exercises, homework, previous exams and solutions of all tasks. It is obvious that all this material is necessary for the student, but it comes with much more content than just the didactic material. Exercises slides, solutions and new lecture slides are useful in order to complete mechanisms which may not be at the slides that already exist, as they belong to the previous course and may have been modified for the current semester.

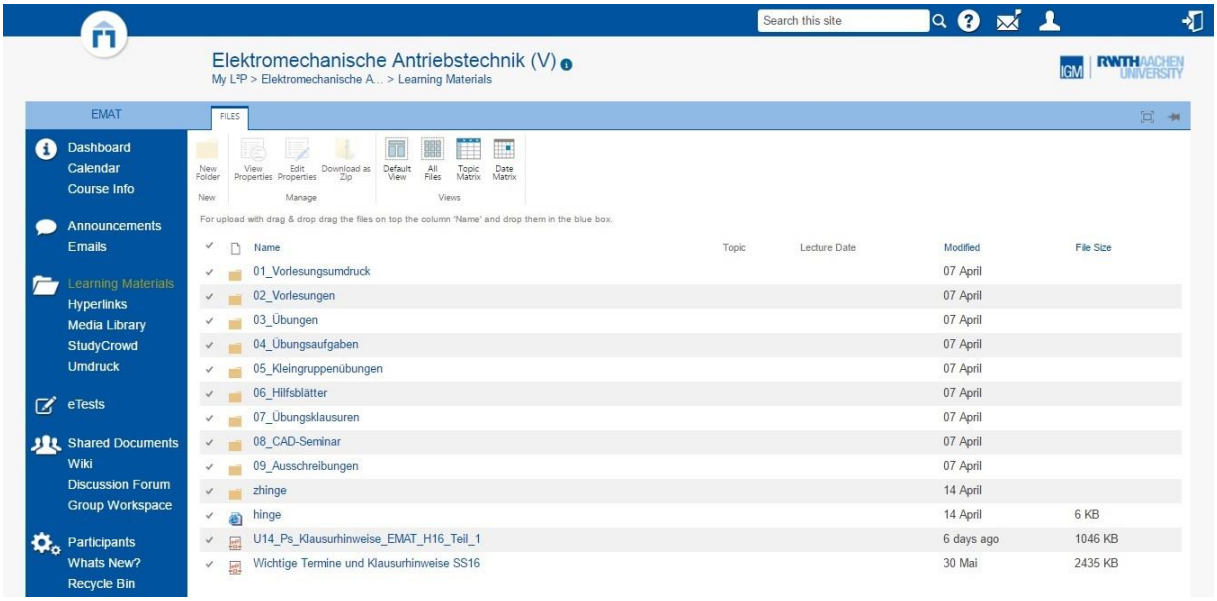


Fig. 3.2: L²P Platform

3.2.3.4 Content provided by DMG Library

The DMG organisation [4] is a search tool related to mechanism theory in which several universities take part (one of them is the RWTH Aachen University). It is a database which gathers information from a large amount of mechanical elements, including the ones addressed in EMAT and BWT. Its operation is quite simplified; the name or keywords of the mechanical element which is going to be analysed is written in the browser, and in the search filter, additional information about the type of file which is desired can be chosen. This database is a very powerful one because it provides many different files: collection, persons, CAx-files, videos, e-lectures, interactive animations, images, mechanism descriptions, software and bibliographic sources. So, it is a really complete source in order to get mechanism descriptions, interactive files and videos.

4 Procedure

4.1 File selection criteria

Among this project neither “Auxiliary sheet” nor “Further tasks” files have been created, as they have been already created in German for the previous semesters and do not need any changes for the future script. Fact which is not applicable to other files as at least small details have to be done to the already existing files.

Two Bachelor students are in charge of the creation and gathering of files during this project. One of them focuses more on the content belonging to EMAT and the other one works mainly with the BWT content. The present thesis deals with the second topic.

Six main groups of mechanisms and mechanical processes are differenciated:

- Transition from a mechanical element to a 2D mechanical scheme
- Existing examples of gear mechanisms
- Motion analysis of planar mechanisms
- Theorem of Roberts
- Kinetostatic
- Gear trains

From now on, the main files related to each group will be selected. Even so, other files may also be created for some particular images, such as relevant examples, or mechanisms which may or not appear in the different sources of information.

4.1.1 Transition from a mechanical element to a 2D mechanical scheme

These figures are shown at the subsection “1.5.5: Transmission systems – Impeller – Examples” of the script. These figures are composed of two different images: the mechanism containing all its parts and links, and also its 2D simplified scheme, as it can be shown in **Fig. 4.1**.

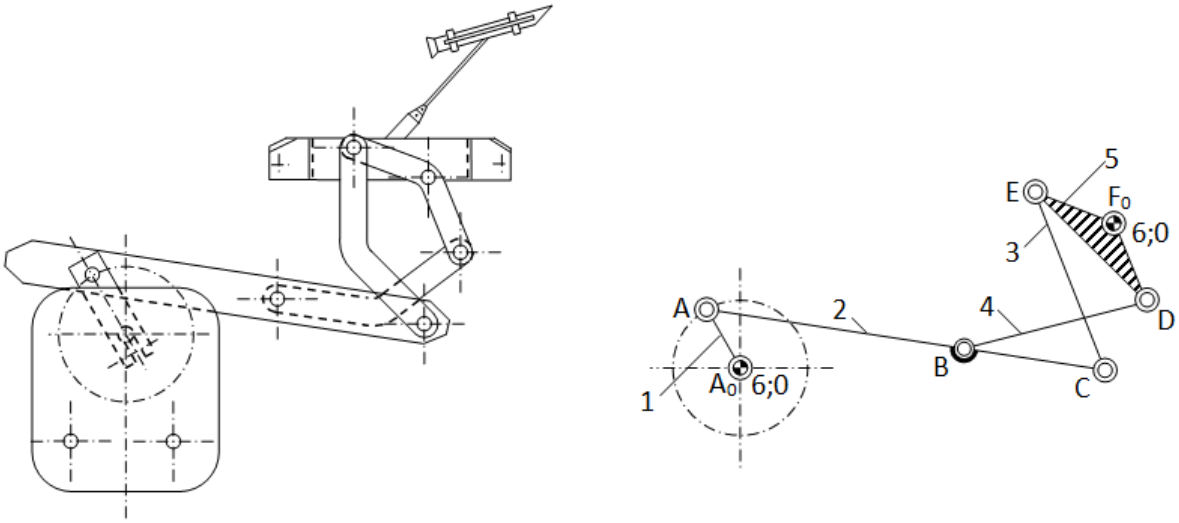


Fig. 4.1: Simplified scheme

In order to explain and represent this type of figures in the prospective script, several files for each figure are considered as necessary.

- A “Description” file to complement the 2D scheme so all mechanical characteristics can be checked at the table and by the scheme (number of links and degrees of freedom among others)
- A “Task” file, so as to show the initial mechanism without the 2D simplified scheme.
- A “Solution” file containing the 2D scheme and the original mechanism, so this file will be the original image from the script.
- The “DMG link” if the mechanism is provided by the DMG library
- An “Interactive” file in case of existing at the DMG Library in order to show how the mechanism behaves.
- A “Video” file so as to show how the mechanism behaves under normal conditions without any changes of its dimensions.
- An “Interactive geometry software” file in order to show how the mechanism behaves when its parameters are changed by the student so as to achieve a complete comprehension of it.

4.1.2 Existing examples of gear mechanisms

These figures are shown at the subsection “1.7: Transmission systems – Examples” of the script. These figures give a more general overview of different transmission systems while the previous group of images provide the schematic understanding of a single mechanism, these ones represent also the realistic interaction between different parts belonging to the same mechanism, as it can be seen in **Fig. 4.2**.

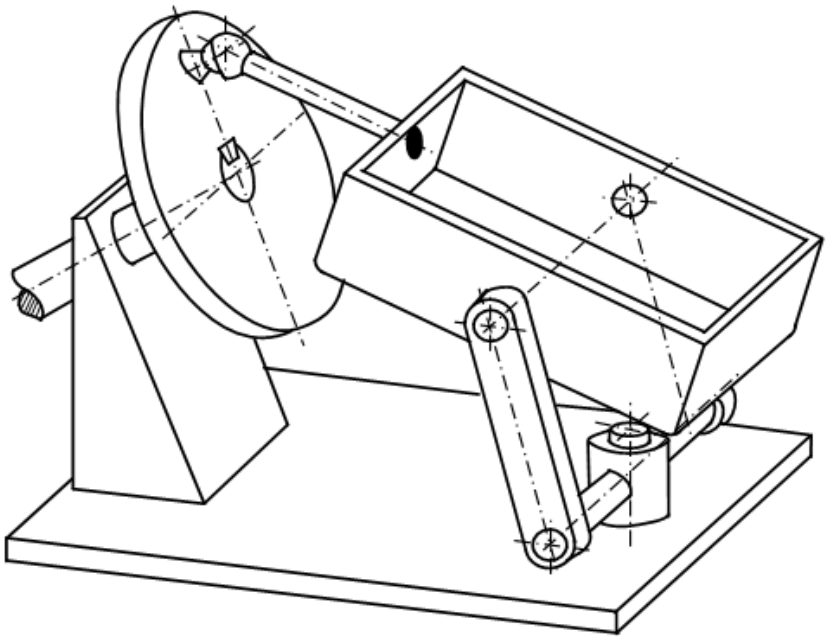


Fig. 4.2: Transmission system

In order to explain and represent this type of figures in the prospective script, several files for each figure are considered as necessary.

- A "Description" file so as to provide the basic mechanical characteristics of the mechanical system which are necessary to achieve its comprehension.
- A "Task" file in order to represent the transmission system, which will be the same figure as the one provided by the script, eventhough it will not be accompanied by a "Solution" file as these figures' aims is not to represent any mechanical process.
- A "Video" file so as to show how the mechanism behaves under normal conditions without any changes of its dimensions.
- The "DMG link" in case that the mechanism exists at the DMG library
- If the DMG Library provides the mechanism, an "Interactive" file in case of existing at that Library in order to show how the mechanism behaves with a possible interaction of the student.

4.1.3 Motion analysis of planar mechanisms

These figures are shown at the subsection "2.2: Transmission analysis of crank mechanisms – Motion analysis" of the script. These figures explain different mechanical and mathematical aspects concerning mechanism motion, such as the velocity and acceleration distribution, calculation of a curve's curvature, representation of centrodes tangent and normal, etc. An example of these figures is shown in **Fig. 4.3**.

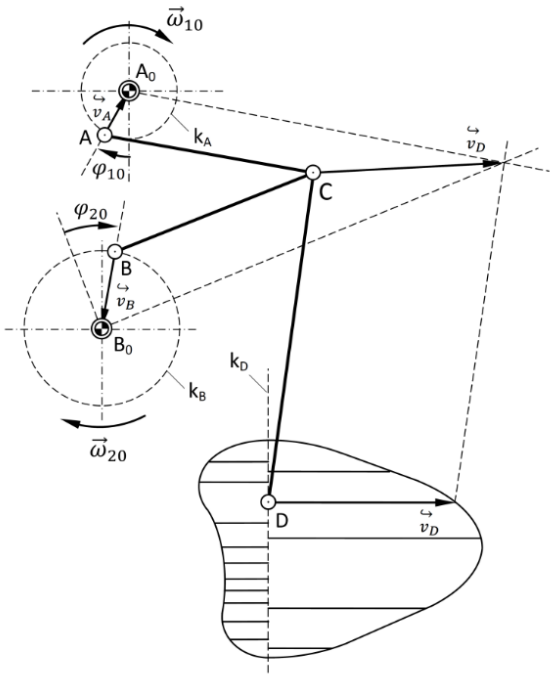


Fig. 4.3: Motion analysis

In order to explain and represent this type of figures in the prospective script, several files for each figure are considered as necessary.

- A “Task” file displaying the mechanism or the scheme before carrying out the analysis.
- A “Solution” file which provides all the analysed characteristics and results.
- A “Step by Step solution” file that progessively shows the different followed stages of the motion analysis leading from the “Task” to the “Solution”.
- A “Recipe” file that sums up the content of the “Step by Step solution” file taking only into account the steps which have to be learnt by heart by the student in order to carry out the analysis.
- A “Calculation” file in case that the analysis of a considered mechanism requires the use of mechanical laws or equations or if throughout the analysis, different equations are deduced.
- An “Interactive geometry software” file in order to appreciate how the analysis changes when varying different parameters of the mechanical element.

4.1.4 Theorem of Roberts

These figures are shown at the subsection “2.3: Transmission analysis of crank mechanisms – Multiple generation of coupler curves” of the script. These figures’ aim is to explain the Theore of Roberts and an example of this mechanical tool at the end. The figures show the different stages of the development of the Theorem of Roberts, an example of these stages can be seen in **Fig. 4.4**.

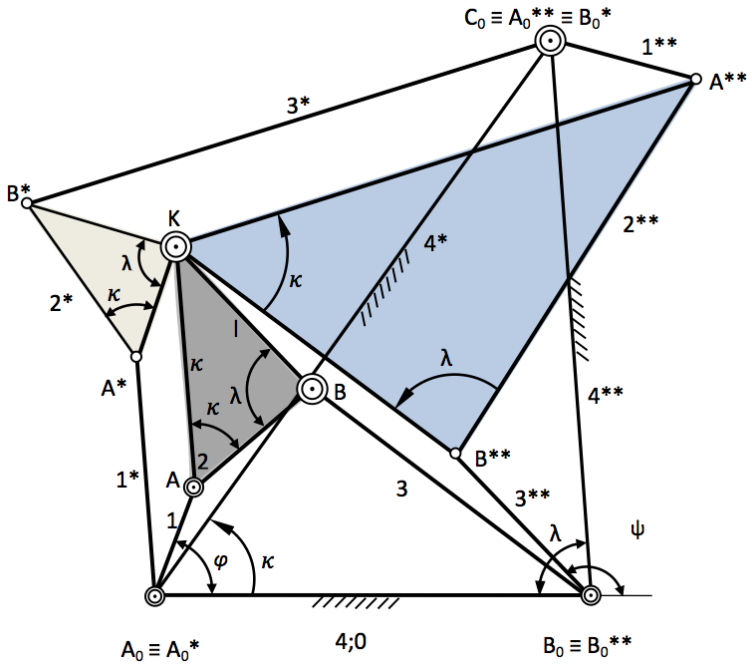


Fig. 4.4: Theorem of Roberts

In order to explain and represent this type of figures in the prospective script, several files for each figure are considered as necessary.

- A “Task” file in order to show the initial state of the stage of the Theorem of Roberts which is described.
- A “Solution” file which displays the result after the different calculations additions to the “Task” file.
- A “Step by Step solution” from the “Task” to the “Solution” file including all required steps.
- A “Recipe” file summarizing the main statements of the stage of the Theorem of Roberts which is described.
- A “Calculation” file in the case of applying any mathematical equation during the different steps or if an equation is derived from those steps.
- A “Video” file displaying the final example’s behaviour.
- An “Interactive geometry software” file so as to complete the process comprehension by adding the possiblity of changing the mechanism/problem parameters.

4.1.5 Kinetostatic

These figures are shown at the subsection “2.4: Transmission analysis of crank mechanisms – Kinetostatic” of the script. These figures represent and explain basic kinetostatic principles, such as: classification and representation of forces and momentum, equilibrium conditions, etc. An example of this kind of files can be appreciated in **Fig. 4.5**.

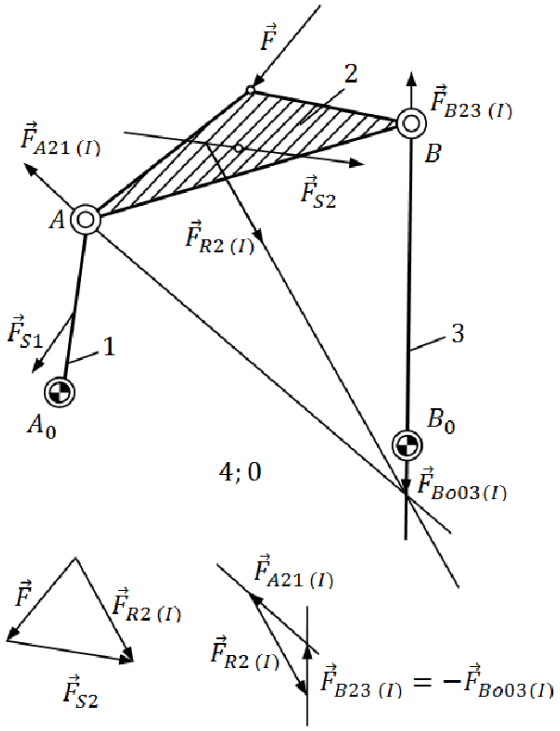


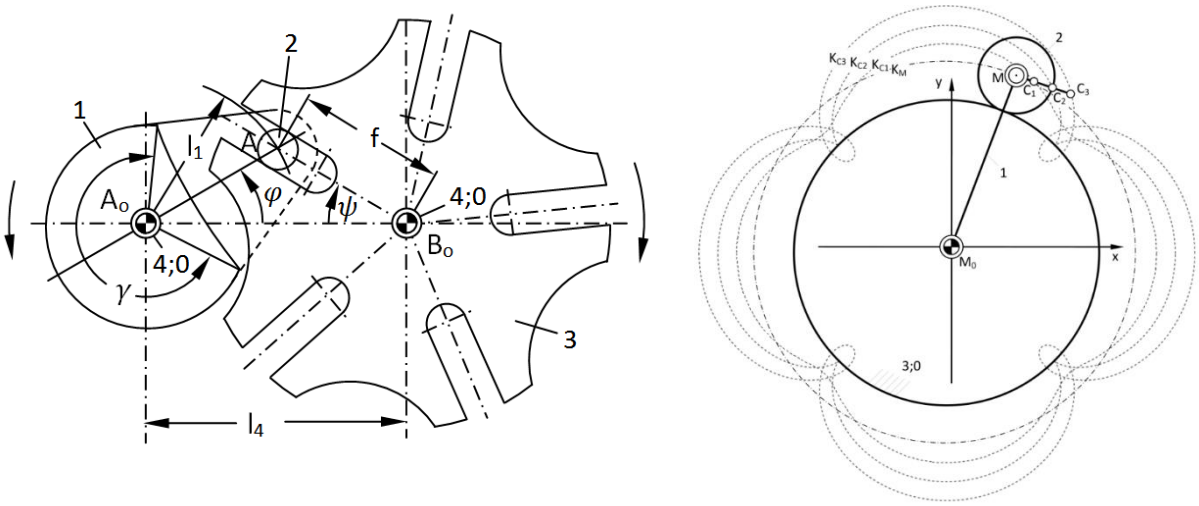
Fig. 4.5: Kinetostatic

In order to explain and represent this type of figures in the prospective script, several files for each figure are considered as necessary.

- A "Task" file containing the problem which is going to be solved applying the mechanical kinetostatic principle that wants to be explained.
- A "Solution" file showing the how the initial task has changed after applying that mechanical kinetostatic principle.
- A "Step by Step solution" with all the different steps leading from the "Task" to the "Solution file.
- A "Calculation" file including different equations taking into account in case of existing, or equations which result from the kinetostatic principle.
- An "Interactive geometry software" file in order to show how these principles are applied under different parameters (changing forces or mechanical structures).

4.1.6 Gear trains

These figures are shown at the subsection "4.2: Further transmission types – Gear trains" of the script. Within this subsection two main groups of gear trains are distinguished: cycloids and planetary gears. Even though, both can be practically described by the same files. Examples of both groups are found in **Fig. 4.6** (a) and (b).



(a) Image 1 **(b)** Image 2

Fig. 4.6: Gear trains

In order to explain and represent this type of figures in the prospective script, several files for each figure are considered as necessary.

- A “Mechanism Description” to give a quick overview of the main parameters and characteristics of the element which is going to be explained.
- A “Task” file in order to show the mechanism or element which is going to be described. This file is usually the original figure from the script.
- A “Calculation” file gathering the required equations for the comprehension of the mechanism’s behaviour.
- A “Video” file so as to see how the mechanism behaves according to the equations shown in the “Calculation” file.
- An “Interactive geometry software” file so the student is able to change parameters of the mechanical element and see how the resulting movement changes (fact that is especially recommendable for cycloids).

4.2 Creation of the files

Here below, the procedure for creating each file is specified.

First of all, a folder for each selected image from the script is created under the name Bild X.Y-Z, S. SSS, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.

4.2.1 Mechanism description

As it is stated at the evaluation of files section, there are several ways to obtain the description of each mechanism.

Three main sources of information are considered: DMG library, Mechanism-Model-Collection and the script.

The DMG library offers a browser and a search filter in order to find the descriptions of many of the mechanisms described in the script. Moreover, as it is a platform where different universities take part in (RWTH, TU Ilmenau, University of the Basque Country, Politehnica University of Timisoara, French Institute for Advanced Mechanics and University of Cassino), the information is found in English, German, Spanish, Romanian and Italian, so the mechanism description are taken from the English versions. The library offers the basic properties in order to characterise a mechanical element (see **Fig. 4.7**), so it will be used as a guide for creating the mechanism descriptions files from other sources.

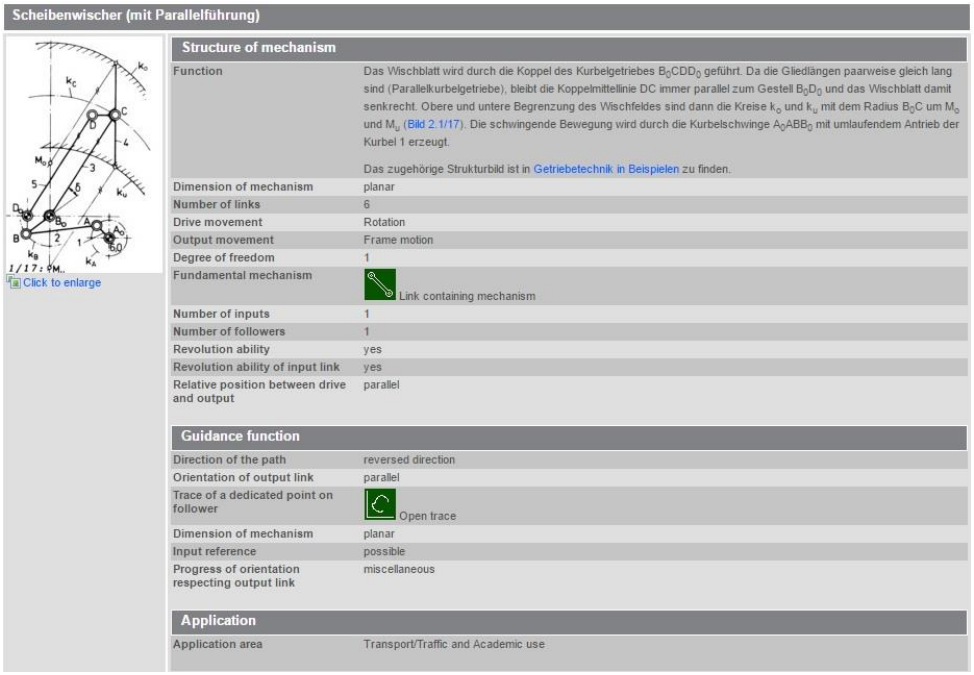


Fig. 4.7: Mechanism description

The Mechanism-Model-Collection provided by the IGM institute offers a description structure similar to the one offered by DMG, fact that facilitates the visual homogenization of files. In some cases, it offers less characteristics than the previous library, but both can always be complementary to each other. However, it also offers the descriptions of mechanisms which can only be found at the institute database and do not appear in the DMG platform, so this library is indispensable for the explanation of certain specific mechanisms.

Both libraries provide all information already structured in tables containing characteristics, but there are some files which cannot be found in any of them, because those elements may be basic

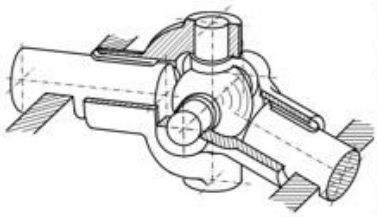
examples or mechanical bodies which explain theoretical concepts. In these cases the information can be obtained from the script.

Hence, a second lecture of the script must be done but this time regarding the collection of descriptive information. Once this information is identified, it is completed with the information provided by both libraries. Occasionally the script does not provide specific information which is required for the description, so these characteristics have to be fulfilled by the developer of the project and checked by the supervisor.

Once all necessary information has been gathered, it is time to create the files. These files are made in a power point slide and consist of a table and an image (see **Fig. 4.8**).

The table is subdivided into two columns, one contains the characteristic parameter name, and the adjacent one the information of the mechanism related to that parameter. Both have a width of 15 cm in all the files in order to fit and have the same pattern in the future online script. At the left of the table a representative image of the described mechanism is located. The maximum width of the image is 8 cm, but in case of being a vertical image, its width will be indicted by its height, which will be the same as the table height.

Each file is saved under the name: Description – Bild X.Y-Z, S. SSS.pptx, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.



Function	
Dimension of mechanism	Spherical
Number of links	3
Input movement	Rotation
Output movement	Rotation
Degree of freedom	1
Fundamental echanism	Link containing mechanism
Number of inputs	1
Number of outputs	1
Revolution ability	Yes
Revolution ability of input link	Yes
Relative position between input and output	Intersecting
Transfer function	
Output motion	Revolving
Transfer function	Identical direction
	Partially in-/ decreased transfer velocity
	Point symmetric
	Specified mathematical function

Fig. 4.8: Mechanism description file

4.2.2 Task

These type of files are represented by the starting element of the problem which is going to be solved or the mechanism which is going to be explained (see **Fig. 4.9**). Be that as it may, the image of the file represents the initial situation may or not be contained in the script.

In the case that the initial image is contained in the script, it is obtained in the original format from the L2P platform, as all images from the script are available at the section "Learning Materials", and are classified by the script chapters and subchapters.

In the event that the initial image of the process which is going to be explained is not provided by the script, it can be obtained by using the final image and an image editor (it may be incorporated in the Power Point program in order to remove backgrounds or Adobe Photoshop for more complex images) so as to delete de final solution and intermediate steps in case that the final image has them.

Once the initial image that is going to be used as the starting point of the mechanism is created, it is added to a one slide power point, as this is the final format of the file. The picture is placed in the centre of the slide or in the position where the initial steps begin in order to keep the same pattern of the solution and step by step files. If the picture loses quality after editing it, the Power Point program itself offers the possibility of balancing its brightness, contrast and clarity.

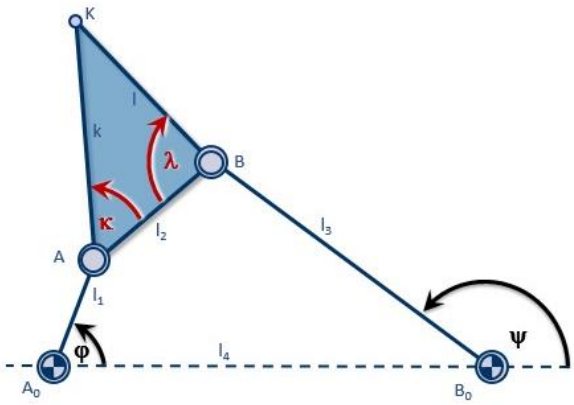


Fig. 4.9: Task file

Each file is saved under the name: Task – Bild X.Y-Z, S. SSS.pptx, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.

4.2.3 Solution

These files show the final state of the mechanical explanation or theoretical development (see **Fig. 4.10**). They are made with an image that may represent the solution of a mechanical exercise or a conceptual development. These pictures can be found in the script, which are provided by the L2P platform of both subjects. However, if the script provides the initial image

but has no representative image of the final state, it can be created by using the "Step by Step" files, as it is an image including the result after implementing the steps sequence.

Once a representative image of the mechanical process' final state is created, the possibility of including all the intermediate steps is to be assessed. In case of being a theoretical process the option of having a look at the equations which have led to the solution is advantageous. In contrast, if it is a process describing the functioning of a mechanism, an image which shows the difference from the initial state is more suitable for its comprehension.

Once the image which represents the solution is created or saved from the L^2P, it is inserted in a one slide Power Point presentation as it is the final format of the file. The picture is placed in the same position and with the same size as the picture in the corresponding "Task" file, or if the mechanism is moved throughout the "Step by Step" file, then the picture is placed at the same point where the sequence of steps ends.

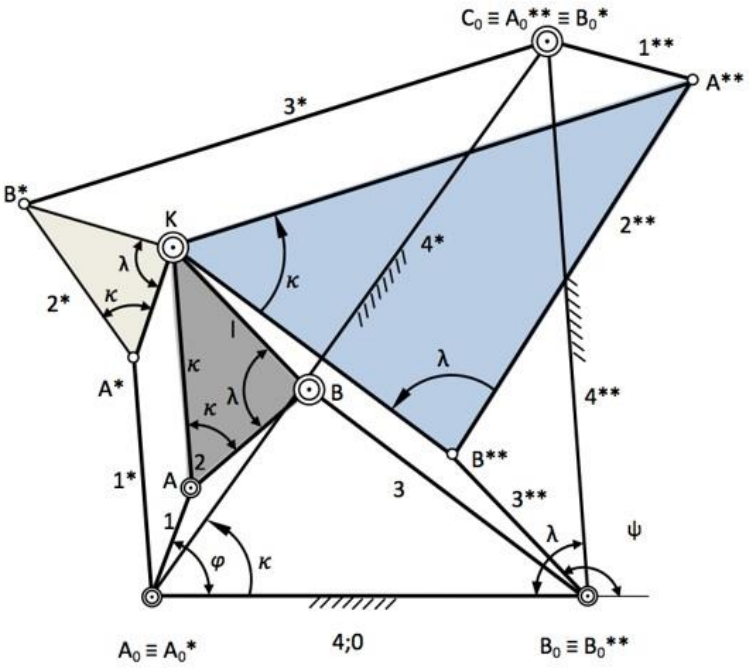


Fig. 4.10: Solution file

Each file is saved under the name: Solution – Bild X.Y-Z, S. SSS.pptx, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.

4.2.4 Step by step

These files represent the process from the image of the "Task" file to the one of the "Solution" file.

These files are also created in a Power Point format, so the first slide corresponds to the "Task" file and the last slide is the "Solution" file.

There are different ways to obtain the sequences of steps to follow. Often, these sequences may already exist in the Lecture slides of the previous semester. Beforehand those presentations have been revised in order to find where the different mechanism are placed. In this case, the slides concerning a mechanism are copied into a new file. Once the new file is created, additional information in the slides is removed (slides numeration, IGM stamp…) leaving just the necessary graphic elements (arrows, textboxes, arcs…) which conform the step by step animations.

In case that the sequence of steps is not represented in the collection of the previous semester's slides, they are created from scratch in a new Power Point file. Initially, the information is obtained from the script and transformed from a descriptive format to a numbered scheme format. Subsequently, starting from the image from the "Task" file, different required graphic elements are added, being grouped with the same animation those that belong to the same step in the new schematic description. Once all steps have been represented, the visual aspect is homogenised; increasing lines' width and using the same colours for the different elements and their labels (see **Fig. 4.11**).

Finally, the location of the first and latest images must be checked as they have to be placed in the same position as in "Task" and "Solution" files. Otherwise, these two files would be edited so the online script shows three different files but sharing the same size, proportion and position format, in order to offer a more clear and structured content.

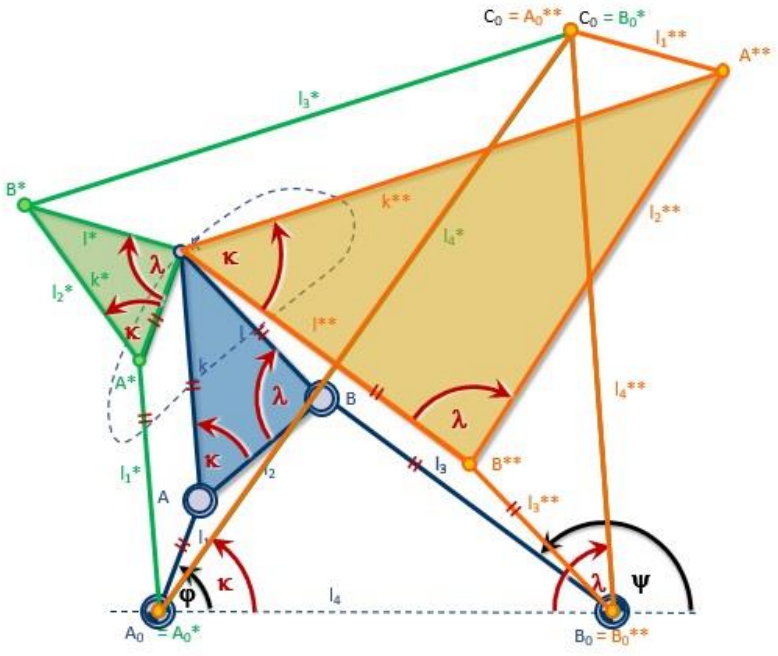


Fig. 4.11: Step by step file

Each file is saved under the name: StepbyStep – Bild X.Y-Z, S. SSS.pptx, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.

4.2.5 Recipe

These files are created parallel to the “Step by Step” files or just after them, as the “Recipe” files represent a summary of the “Step by Step” ones.

Two different types of files are considered; the ones with simple and easy to distinguish steps, and the more complex ones.

In the first instance, the transitions between steps are deleted so it results in a one single image file showing all steps, each one in one different colour. Next to the image, a textbox is added, containing all numbered steps written in the same colour as the step they represent (see **Fig. 4.12**).

In the second instance, as the general image with all the steps results too complex and unclear, the transitions from the “Step by Step” file are kept, adding different textboxes for each step, so as to get a final slide with all previous steps but in a more comprehensive way.

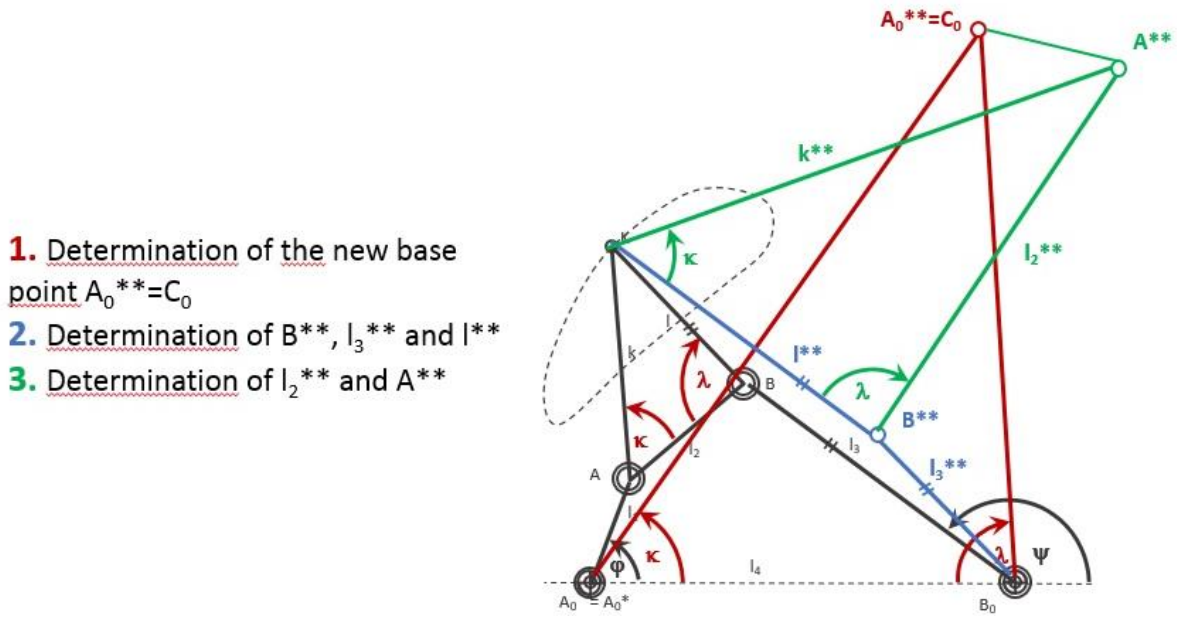


Fig. 4.12: Recipe file

Each file is saved under the name: Recipe – Bild X.Y-Z, S. SSS.pptx, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.

4.2.6 Calculation

These files collect the theoretical content of the element which is being described. Two different files can be created: descriptive or mathematical ones.

The descriptive ones collect theoretical information of the mechanical element: classification or the different components of the mechanical law or equation they follow. In case of belonging

to a classification, the "Calculation" file gathers a table (see **Fig. 4.13)** which brings the classification of the element, and that table will be created in a slide in a power point file. The table may be provided by the script, so its creation can be reduced to a translation of its content and creation of an analogous one.

	Four-element output gear	Five-element spare gear
Crank 1	$l_1 \equiv \overline{A_0A}$	$l_1' \equiv \overline{A_0A} = l_1$
Crank 2	$l_2 \equiv \overline{AB}$	$l_2' \equiv \overline{AK} = l_2 \frac{l_4^*}{l_4}$
Swing (coupler) 3	$l_3 \equiv \overline{BB_0}$	$l_3 \equiv \overline{A^{**}K} = l_3 \frac{l_4^*}{l_4}$
Crank 4	-	$l_4' \equiv \overline{C_0A^{**}} = l_1 \frac{l_4^{**}}{l_4}$
Rack 4 and 5 respectively	$l_2 \equiv \overline{AB}$	$l_5 \equiv l_4^* \equiv \overline{A_0C_0}$
Determiners of the coupling point	$\kappa \equiv \overline{AK}$	$k' \equiv \overline{AK} = k$
	κ	$\kappa' = \kappa - \alpha$

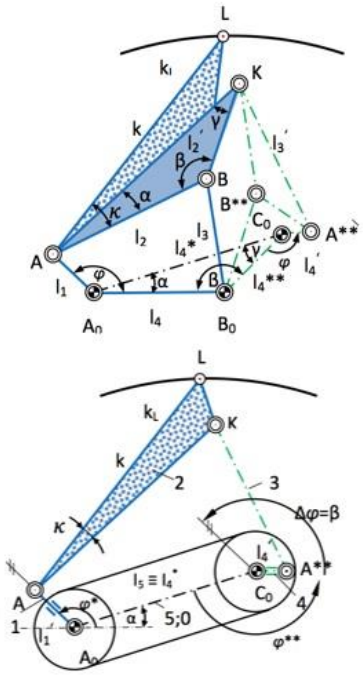


Fig. 4.13: Calculation - classification file

Alternatively, if the "Calculation" file's aim is to show the mechanical laws and equations the mechanism follows, the file will include these equations and the significate of each one and its components (see **Fig. 4.14**).

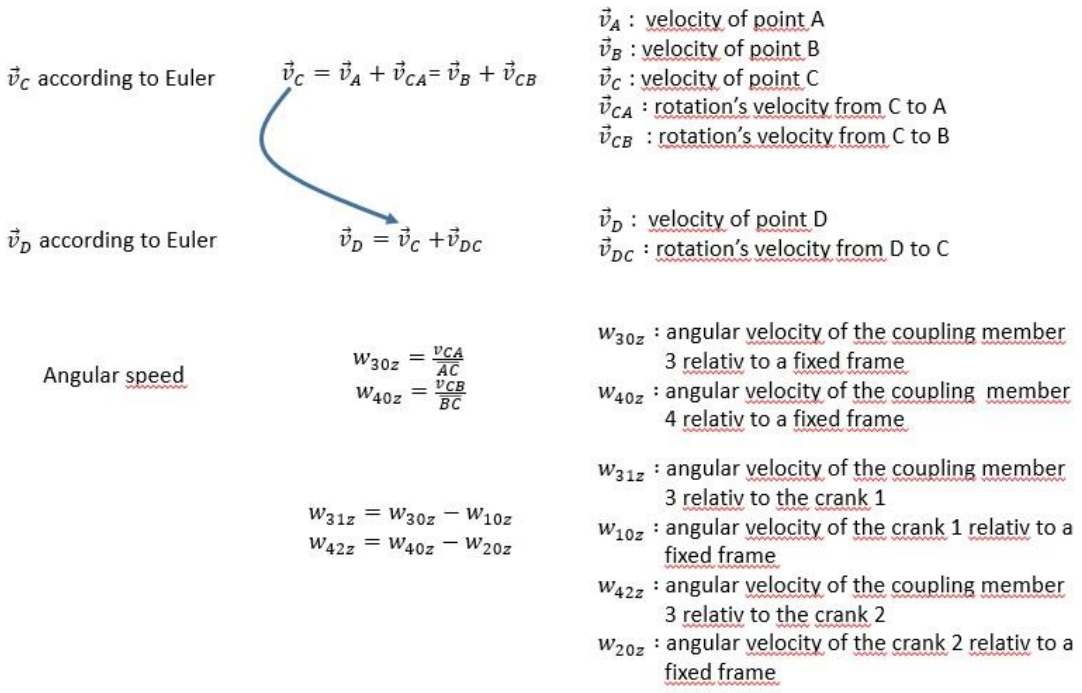


Fig. 4.14: Calculation - descriptive file

The mathematical "Calculation" files (see **Fig. 4.15**) gather the theoretical development leading to the final equations which constitute the mechanism behaviour. The set of needed equations are provided by the script. In order to create these files, the involved equations are gathered and also the relations between them and explanations. Once all the necessary information is collected, the file can be created, which is a Power Point file. Between each equation, the description of the mathematical process which leads from one to another has to be shown. If the theoretical development results too messy, the animations used in the "Step by Step" files may be used, so as to simplify and clarify the aforesaid development.

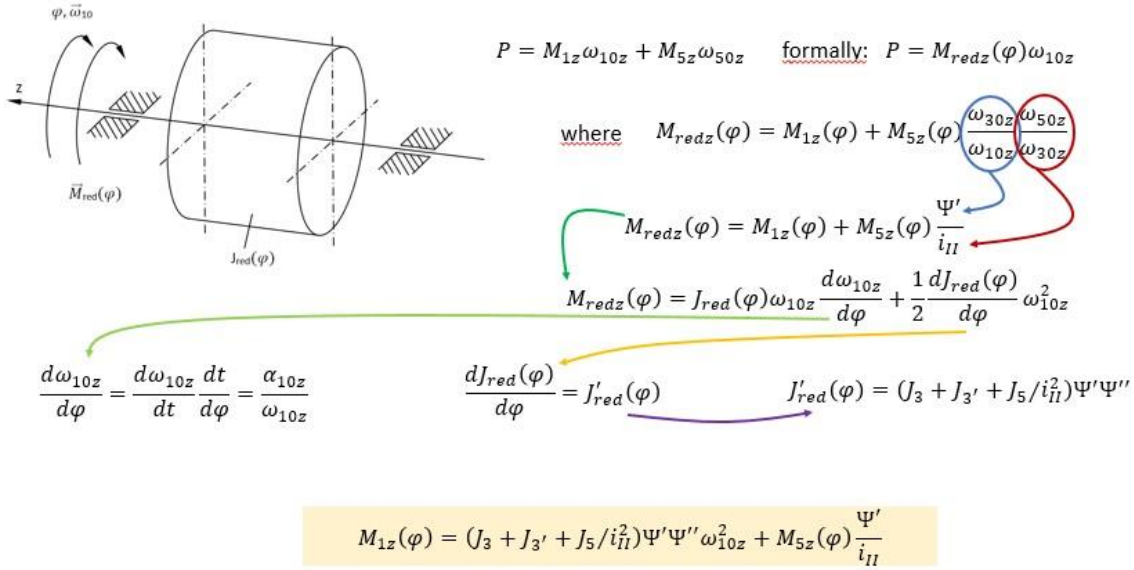


Fig. 4.15: Calculation - mathematical file

Each file is saved under the name: Calculation – Bild X.Y-Z, S. SSS.pptx, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.

4.2.7 Interactive files

These files (see **Fig. 4.16**) are not created but gathered. The principal source which supplies them is the DMG library.

In order to collect these files, the name of the mechanism is typed in the browser as it is done for the purpose of creating the “Description” files, but selecting “interactive animations” in the search filter.

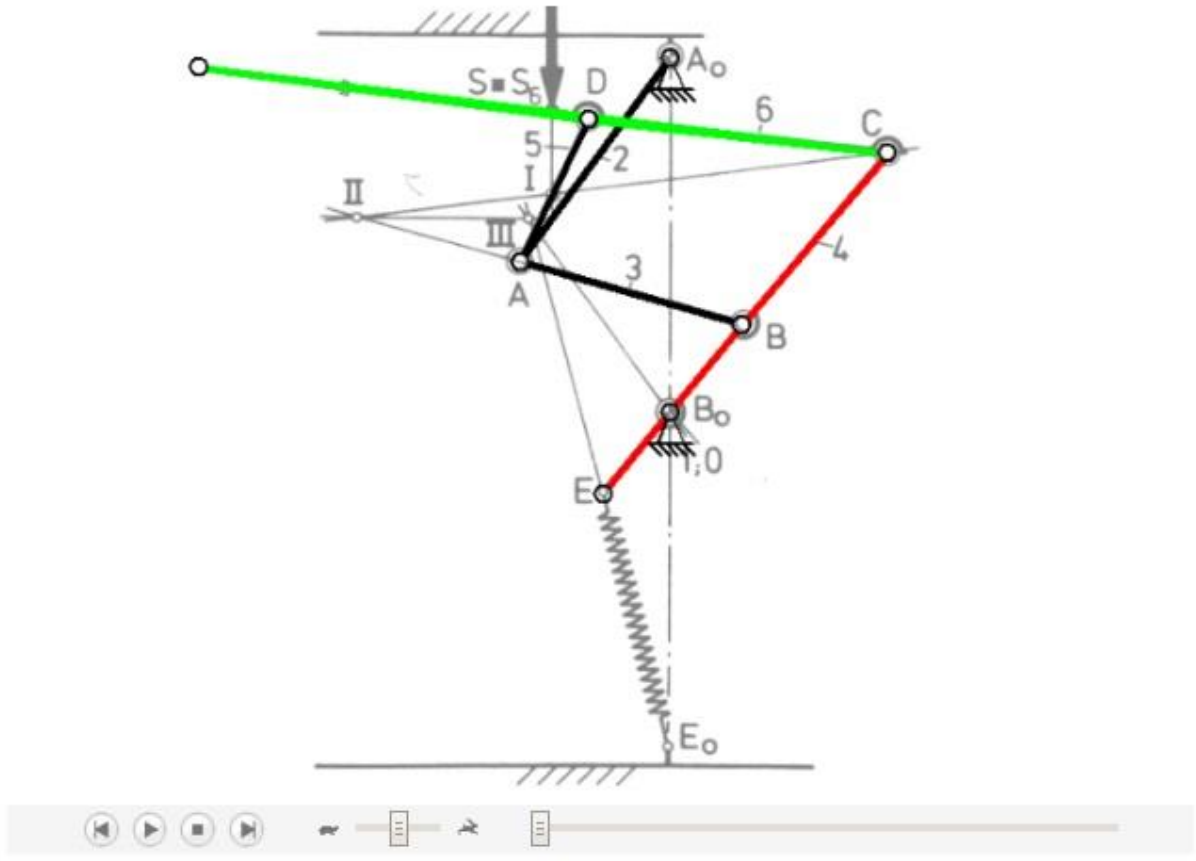


Fig. 4.16: Interactive file

Once the desired file is found, it is saved in two different ways. Firstly, the link which leads to that file is saved, and also, the website is saved, creating a folder that contains all the information shown on that webpage under the name: Interactive – Bild X.Y-Z, S. SSS, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown. In this folder, all images and elements that belong to the website are downloaded.

4.2.8 Interactive geoetry software files

There are three different sources for the obtaining of these files:

- The first one is the DMG library, in which just by choosing "interactive files – Cinderella" in the search filter, the user can get these already created files.
- The second one is the Mechanism-Model-Collection provided by the IGM institute, which offers links to the IGM mechanism library of 207 different models. From this library GeoGebra files (see **Fig. 4.17**) of most mechanisms can be downloaded, along with CAD files, animation and images rendering.
- The third one is the previous semester's slides. During the so called "Lecture" sessions throughout the semester, several of these files are used as complementary learning material to the slides, as the slides offer links to different Cinderella (see **Fig. 4.18**) or GeoGebra files which are included in the same folders as the presentations are. So the

geometry software files can be selected directly from the collection of slides the desired files and saved them under the name: Geometry – Bild X.Y-Z, S. SSS, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.

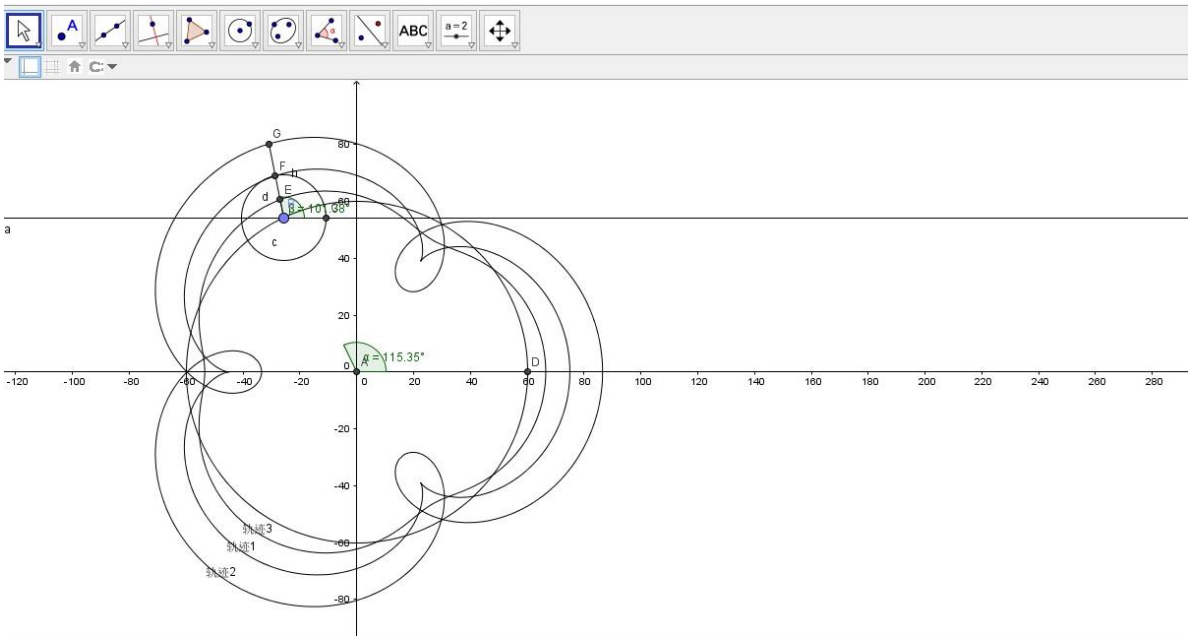


Fig. 4.17: GeoGebra file

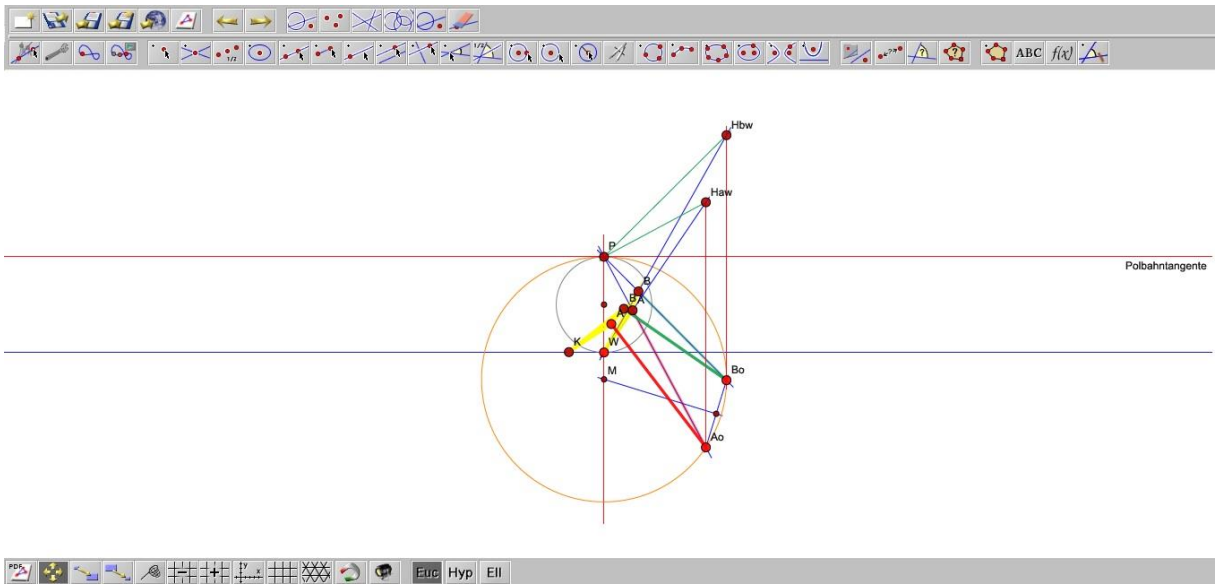


Fig. 4.18: Cinderella file

4.2.9 Video

The same way it happens to the “Interactive geometry software” files, also three sources provide videos.

Firstly, the DMG library offers videos (see **Fig. 4.19**) of several mechanical elements’ operating mode in different formats and size. In this case, videos with the highest quality are downloaded as the definition of the image is the best one and they can also be compressed if they should take up less space. Likewise, the same procedure is followed in case of being the Mechanism-Model-Collection the source of videos.

Conversely, if the required videos are used in the “Lecture” slides, the original video file is copied and saved in the mechanical element’s folder for an easier identification.

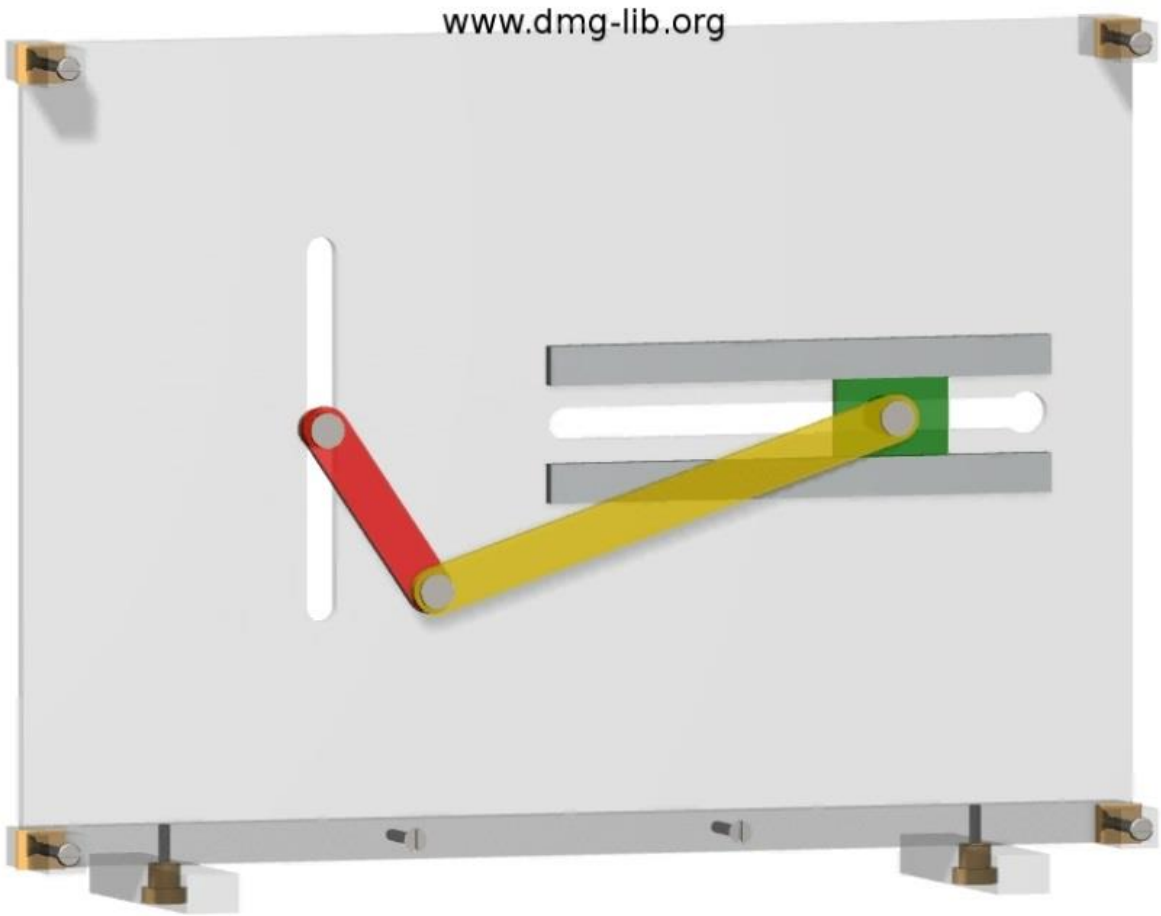


Fig. 4.19: Video

Each file, regardless of the source it comes from, is saved under the name: Video – Bild X.Y-Z, S. SSS, where X.Y-Z is the designation of the mechanism or image in the script and SSS is the page where it is shown.

4.2.10 DMG links

As it was mentioned before, the possibility to access to the mechanism's DMG website (see **Fig. 4.20**) which gathers information of it, is offered to the students. The way to keep all that information is by saving the link that leads to that website.

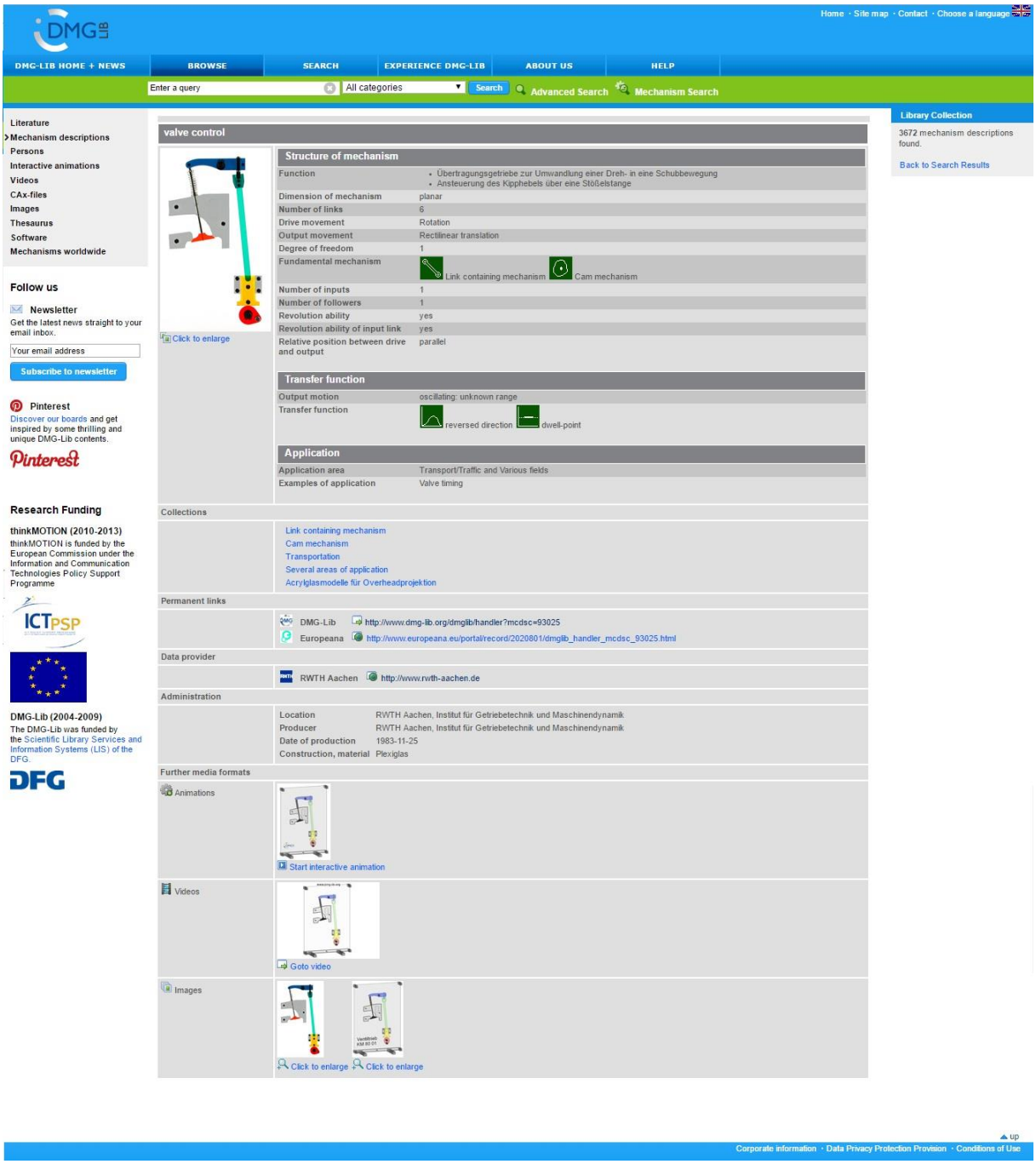


Fig. 4.20: DMG link

5 Summary and Outlook

After carrying out this project 412 files from 104 figures from the script have been gathered.

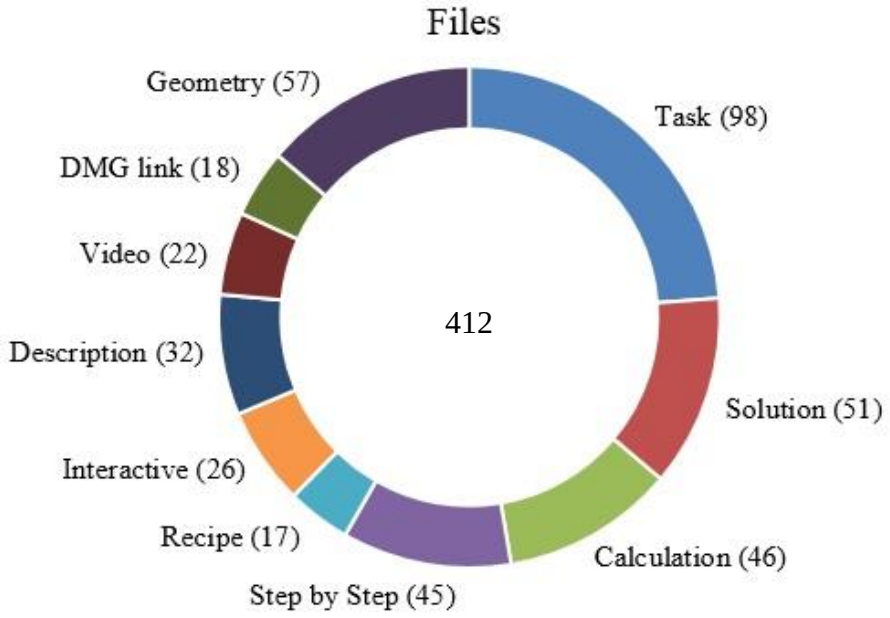


Fig. 5.1: Collection of final files

As can be seen in the graph above (see **Fig. 5.1**), "Task" files have been the more created ones, as almost every mechanism or mechanical description needs an initial situation in order to start an explanation. In the second place, "Solution" and "Geometry" files are distinguished. On the one hand, "Solution" files are required in order to complete a mechanical description, while on the other hand "Geometry" files are used to display a mechanism's behaviour. This similarity of files quantity roughly differentiates the two main groups of knowledge that have been developed; tangible mechanisms and mechanical descriptions and theorems.

Furthermore, the accomplishment of this project allows the review of the subject matter, adjusting it to the necessary and useful information the student needs. In addition, the project's executors are able to find possible gaps of the existing teaching method as all the documentation and didactic material offered to the students must be checked. This checking progress allows the evaluation and reconsideration of the potential usefulness of this information for the new developed didactic method.

Further progresses may be made after the project's completion. Firstly, the language used in the files should be unified, as both subjects are taught in German while the mechanisms and mechanical processes concerning this project have been developed in English. This apparently negative aspect may lead to a prospective English teaching of the Theory of Mechanism at the RWTH University. This enlargement of the number of students capable of following both

subjects, results in a greater capacity of knowledge exchange, fact which is basic for the University development and improvement.

Regarding the consequencies for the IGM institute, after the finalisation and implementation of this project several statements are obtained, such as reception of the new teaching method by the students, user-friendliness, detected mistakes or disadvantages compared to the script. Once these results are assessed, the possibility of realising this project concerning other subjects belonging to the insitute may be raised, so as to upgrade and update the teaching methods.

This project is a portion of the main project which aims to create a new didactic method, which includes the development of the website where all information will be shown, and the creation and harvest of all the necessary data. It means the actualisation and aproach of the teaching system towards the students, providing them a more attractive and close aspect of the subject matter and therefore a higher convenience when studying both subjects with this new didactic method. As a positive impact on the immediate environment of the University, this project may lead to a generalised change of the teaching methods in technical subjects, allowing that these methods move forward as the different advances the students use in their day-to-day life.

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List of figures