

## EXAMPLES OF USING THE CAD CONCEPT AND CAE CONCEPT IN THE STUDY OF BASIC TECHNICAL SUBJECTS

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**Abstract:** *The specialized programs for computer graphics, which are adequate to the CAD and CAE concepts, with the exception of their main purpose, can also acquire equally important and useful teaching capabilities. For students, the study of some difficult and abstract theoretical issues can become attractive and friendly if the computer and its representation capabilities are used. This article shows a few examples which plead in favor of generalizing the use of the capabilities offered by computer graphics in the study of some geometric properties of modeled figures or plane sections.*

**Key words:** *Mass properties, CAE, solid modeling, Solid Works, revolution bodies.*

### 1. INTRODUCTION

Not so long ago, only the big companies could afford the luxury of owning CAD systems. These were very expensive systems, equipped with unique software, either developed using one's own resources or commissioned. The „democratization” of computer science made the CAD systems accessible to anyone. Nowadays, any piece of equipment can be used in designing, provided that it is supplied with an adequate software pack, just as the AutoCAD or Solid Works programs are.

The solid model of a figure is the virtual numeric shape of the geometric position of the points in space occupied by that figure. It is built by starting from the characteristics of the figure and using the wire frame and mesh networks models. The solid model contains all the information related to the entire volume of the figure, being the most complex, the clearest and the least ambiguous form of modeling. It is well known that the most pleasant way of approaching the study of a problem is, at the same time, the most efficient one. Therefore, students can use solid modeling as an attractive and captivating method for the study of the double orthogonal projection representations, from general solid

figures to most specific aviation techniques.

### 3.1. REVOLUTION BODIES

Solid modeling (for or by the students) can be used in the study and representation of the category of such popular revolution bodies as the flanges, bushes, sleeves, shafts, lids etc.

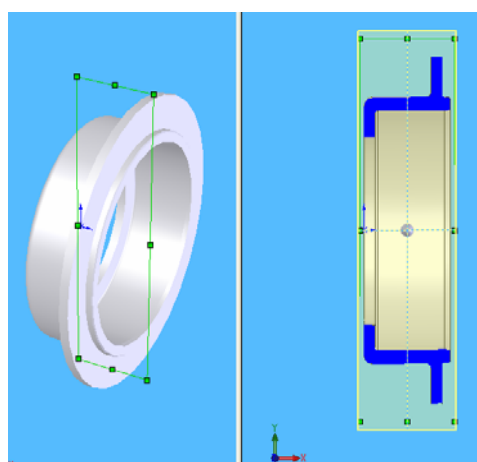


Fig. 1 Revolved bodies

Unlike the aforementioned situations, in this case we have a piece with the dimensions specified - the respective diameters of the surfaces, the distances onto which those diameters are distributed, the bevels and the junction rays. All these geometric elements

will be used when forming the solid model which, obviously, is obtained by rotating a certain profile around the rotation axis of the body

Figure 1 and figure 2 presents the image of the 3D model and, next to it, one or two axial sections.

This type of approach, of solid modeling and model analysis, is very efficient and attractive. In general, it can be used in the modeling of shafts or of the cinematic chains' shafts, for example in the modeling of the movement mechanisms used in upward or downward direction in anti-aircraft cannons.



Fig. 2 Solid model

To point out the shape and the dimensions of the voids of the body, the groove keys, the bores etc. mobile sections can be used, conveniently chosen after the section plan (axial, transversal or inclined), with a certain predefined ratio of the moving of this plan.

For example, figure 3 presents such a succession of sections.

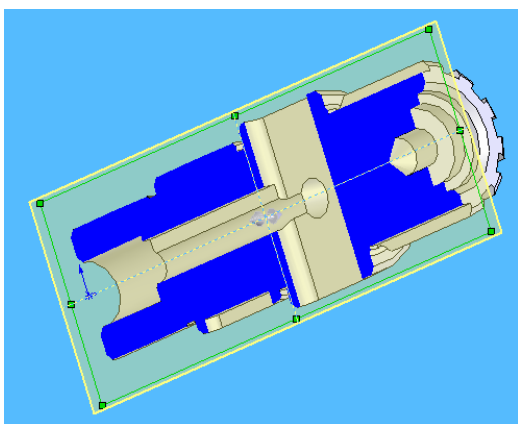


Fig. 3 Section view

### 3.2. POLYHEDRONS

A certain type of exercise, meant to foster the students' capability to abstract, as well as their abilities to represent 2D models, is to determine the lateral projection of a figure, if the vertical and horizontal projections are known (figure 4).

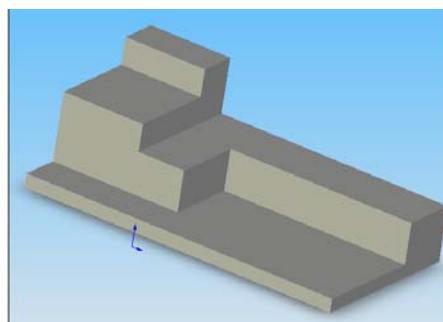


Fig. 4 Projections

The students with great effort solve this exercise, presented in figure 1, with a simple solid figure, a combination of right prisms. However, if solid modeling is used for this very figure, either by the teachers or even by the students already familiar with using a specialized program, the whole procedure becomes more efficient and more attractive.

### 2. THE CAE CONCEPT

There is a very wide range of phenomena whose evaluation is compulsory in the analysis phase of a project. This evaluation is accomplished with the help of the computer and the specialized programs destined to this objective. For instance, the analysis of the way in which a mechanic system behaves from the viewpoint of the strength of materials or their rigidity (from the standpoint of the distortions), the analysis of the cinematic sizes at the driven element in the case of a mechanism, the tracing of the rod curves, the checking of the mobility of a cinematic chain, the animated representation of the functioning of a mechanism, the tracing of the motion, speed and rod push acceleration curves of a cam mechanism, the mass centers and the moment of inertia calculation, etc. All these aforementioned software packs are part of the CAE category.

Therefore, the CAE objective is to analyze the geometry performed with the use of the CAD techniques, allowing the designer to simulate and study the way in which the product behaves so that the project can be optimized.

Generally speaking, the analysis is performed on a virtual, abstract model, which is conceived for this very purpose and it is built based on the geometric model created in the synthesis phase. The CAE software converts the geometric model into an analysis one in an interactive way (through the dialog bar of the program, which constantly asks for the sizes and data necessary to the analysis).

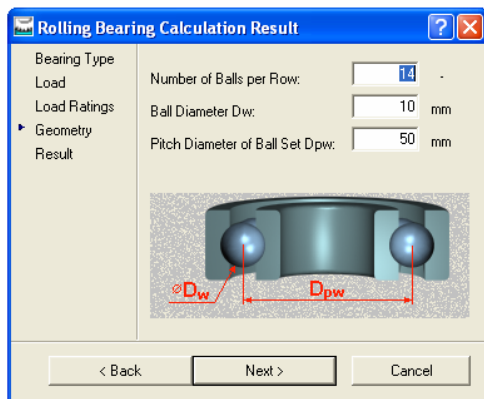


Fig. 5 A dialog box

The programs that perform the building of the analysis model are called preprocessors and they run the analysis mathematical algorithms within some executables, named processors. These generate the results under the form of some data files, organized in tables. Finally, for these data to be interpreted and evaluated more directly there are postprocessors programs that offer the user various possibilities of graphic visualization: chromatic fields, diagrams, animated graphic motion.

The programs included in this category are very diverse and they practically cover the whole field of car components design, from assembly to shafts, laminated profiles, elastic elements, grooves, gears, and bearings. Figure 1 illustrates a dialog box through which the program is interactively asking for some geometric elements of a ball bearing to be introduced. This example is one of the simplest, though it does show a common

element of these CAE category programs, i.e. the way in which the computer assumes the calculation and the representation of some mechanic elements, how it offers additional information (related to strength, durability, material, sizes, distortions, etc), and how it also signals potential errors which might appear in the design stage. Thus, it is possible to perform rapidly and easily data storage, manipulation, modifications, and recalculations, in other words, an analysis of the adopted solutions.

## 2.1. MASS PROPERTIES

The theoretical solutions and the calculations of the weight centers, static moments and moments of inertia, necessary to the study of some section properties, as well as material strength or theoretical mechanics, can be presented and verified with the help of assisted graphics (CAE). In this manner, the presentation becomes clearer and more attractive, whereas the students acquire the abilities of maneuvering specialized software used in engineering evaluations and calculations.

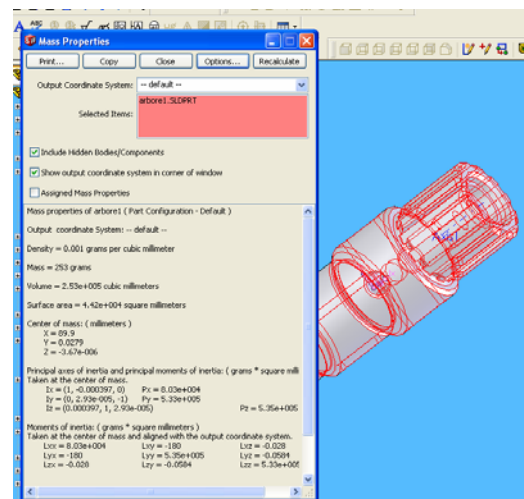


Fig. 6 Mass properties dialog box

In figure 6 we can see a dialog box of the 3D design and modeling program Solid Works, an “open source” version, displaying the mass properties of a solid model. All the values that are displayed and which will be reproduced in detail below relate to the planes of the trihedral in relation to which the solid modeling has been created.

It is given the solid model presented in figure 3, a combination of right prisms. The values displayed in the program's dialog box for the mass properties of this body are:

Mass properties of solid7 (Part Configuration - Default)

Output coordinate System: -- default --

Density = 0.001 grams per cubic millimeter

Mass = 118 grams

Volume = 1.18e+005 cubic millimeters

Surface area = 2.5e+004 square millimeters

Center of mass: (millimeters)

X = -2.65

Y = 11.7

Z = -50.3

Principal axes of inertia and principal moments of inertia: (grams \* square millimeters)

Taken at the center of mass.

$I_x = (0.994, -0.104, -0.0427)$        $P_x = 3.99e+004$

$I_y = (-0.0193, 0.217, -0.976)$        $P_y = 1.55e+005$

$I_z = (0.111, 0.971, 0.214)$        $P_z = 1.81e+005$

Moments of inertia: (grams \* square millimeters)

Taken at the center of mass and aligned with the output coordinate system.

$L_{xx} = 4.17e+004$      $L_{xy} = -1.46e+004$      $L_{xz} = -5.5e+003$

$L_{yx} = -1.46e+004$      $L_{yy} = 1.78e+005$      $L_{yz} = -4.8e+003$

$L_{zx} = -5.5e+003$      $L_{zy} = -4.8e+003$      $L_{zz} = 1.56e+005$

Moments of inertia: (grams \* square millimeter)

Taken at the output coordinate system.

$I_{xx} = 3.55e+005$      $I_{xy} = -1.83e+004$      $I_{xz} = 1.02e+004$

$I_{yx} = -1.83e+004$      $I_{yy} = 4.76e+005$      $I_{yz} = -7.42e+004$

$I_{zx} = 1.02e+004$      $I_{zy} = -7.42e+004$      $I_{zz} = 1.73e+005$

## 2.2. THE CURVES CHARACTERISTIC TO A CAM MECHANISM

The analysis of a cam profile is important because it determines the cinematic and dynamic functioning of the mechanism, the variation of the rod push's speed and acceleration, which introduce the inertia forces that will be assumed by the mechanical system. Theoretically, the curve of the rod push motion is studied (the variation law, polynomial, of a certain degree, trigonometric, polidyne cams etc.), then, through successive derivations in relation to a parameter that describes the movement of the leading element, the variation laws of the rod push speed and acceleration are identified.

Figure 7 represents the image of the curves that are characteristic to the rod push of a cam mechanism, as well as that of its speed, motion

and acceleration, obtained with the help of this specialized pack for CAE analysis.

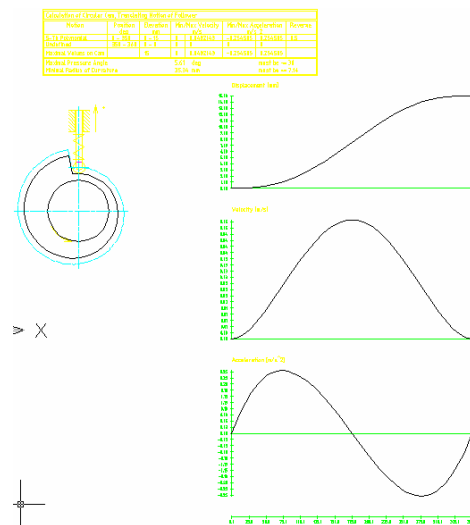


Fig. 7 Characteristic curves to a cam mechanism

Figure 5 illustrates the image of the interactive dialog box, with the use of which the geometric characteristics of the cam are defined.

The program asks for the eccentricity of the cam (or the rod push trajectory) and the rotation speed, and generates a table with the trajectory, speed and acceleration values, presented in figure 7.

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