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## TEACHING COMPUTER AIDED DESIGN FOR ENGINEERING STUDENTS

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**Abstract:** Drawing is one of the main ways of expressing ideas for engineering students. The presentation of graphical information is very important in any project and, in the recent years, the computer solid modeling has become the preferred technique in the mechanical engineering. This paper discusses some ideas about increasing learning efficiency in teaching computer aided design techniques and presents assessment methods, completed with practical examples of multiple choice tests.

**Key words:** Computer Aided Design, Solid modeling, Efficient learning, Teaching methods, Assessment

### 1. INTRODUCTION

Computer aided design (CAD) techniques are widely used today in engineering, almost completely replacing manual sketching and drawing. Some of the benefits are that the working speed and the accuracy are higher, the virtual model can be easily resized, modified and archived, the software offers multiple visualization possibilities and there it is bidirectional associativity between the three-dimensional model and the two-dimensional views. The virtual model can be imported by CAE (Computer Aided Engineering) and CAM (Computer Aided Manufacturing) software that allow: various tests and simulations on the operation and automatic generation of manufacturing technology, including programs for CNC machines.

Three-dimensional modeling may include: wireframe methods, surface methods and solid modeling. In mechanical engineering, designers prefer to work with 3D modeling software packages based on representation of solids. They are considered closer to the natural way of perceiving the environment and greatly help the drafting work, due to their facilities: working with a large volume of data, providing information on mass properties of the model, using the concept of parameterization, etc.

The rapid development of computer aided design field resulted in increased demand for CAD courses in recent years and therefore their importance in education is growing. They must keep pace with the rate of occurrence of new versions of CAD programs and to adapt to the continuously changing requirements of users and of the labor market. Due to the large number of CAD software packages on the market, also the educational offer must be diversified and flexible. The teaching method needs to be developed to meet students' expectations, to ensure fast and efficient learning of basic design techniques and the providing of knowledge on the working features of a specific CAD software package.

### 2. TEACHING COMPUTER AIDED DESIGN

The learning process has three main components: teaching, learning and assessment. The learning efficiency is given by the dynamic interaction between them. Teaching consists of a specific system of actions which aim to promote receiving, accessing and understanding of a particular category of information, for training capacities and skills.

From the professor's point of view, the efficiency of a course is directly proportional

with the ratio between knowledge gained by students and the workload needed for course development [1]. It is important for students to properly understand the course content and to have a positive attitude in relation to learning.

The specific of teaching computer aided design for engineering students is that a course transmits a large amount of visual information, along with a set of rules for processing, in an ordered sequence of steps. In addition to the basic techniques and design rules, students should learn and be able to apply the facilities of computer aided design software packages. Students consider that a course is efficient when there is a high ratio between knowledge gained and the volume of work needed for successful completion of the discipline [1].

Both the way the course is designed and developed and also professor's attitude towards students and his/her teaching experience have decisive role in increasing the efficiency of the teaching-learning process. In this respect the following recommendations are made:

- The course should take account of knowledge acquired by students in previous disciplines, bringing a significant growth in a direction which meets the requirements of the disciplines that will go further and also being a support for them.
- The most effective teaching style for CAD courses involves interactive computer-based multimedia presentation and active implication of students during the course.
- Since the maximum attention span of students is about 15 to 20 minutes, each course session should be structured to include: a short presentation of new concepts, in the beginning, then several short mini-lectures, each followed by application exercises. The course should end with a summary of new learned concepts.
- Students learn faster a new feature if each of them has access to an individual workstation and has to complete a given work task, as application. They should be encouraged to communicate while carrying out tasks, to stimulate each other and to learn from the experience of others colleagues.
- Each student will perform workloads in his own rhythm, because a group usually includes a large spectrum of personal abilities. The

professor must pay individual attention to each student. Application exercises should be diversified and in a sufficient number, to prevent some students get bored while the others are making their tasks.

### 3. ASSESSMENT METHODS

Evaluation or testing enables quantitative and qualitative assessment of the effectiveness of the teaching-learning process. From the point of view of professor, assessment means the end point of the course, after one semester, and involves a synthetic work for the development of exam topics, according to the syllabus. For many students, the assessment is the most important part of the course, which motivates them to learn and which influences their educational path.

An effective assessment must meet a number of conditions, including the followings [2]: to be a learning experience; to be motivating and un-stressful; to be constructive and not destructive; to focus on the learned concepts and not on mistakes; to promote the development of self-evaluation capacities on students; to provide opportunities for thinking, reflection and review; to be applied not only at the end of the course, but also during the course, to stimulate learning;.

Computer aided design is a discipline which forms both theoretical and practical skills and therefore CAD teaching needs a particular feature for assessment. The natural consequence of the fact that much of the activity during the CAD course involves the use of computers is that the assessment of knowledge and skills should be made through a practical test, on computer. Since the engineering education is generally focused on problem solving, also the tests on computer aided design course consist of one or more design problems.

The most common method of evaluation is to give a design problem with many demands, made gradually, which grow its difficulty. Thus, each student will be able to solve some of the requirements, depending on the acquired knowledge and skills. Another option consists of a test that contains several simple problems,

covering as many as possible of the learned concepts. The advantage of the second testing method is that it avoids blocking in case the student can not pass a certain design stage, while solving a complex problem. In the next section, there are some examples of simple problems which author has used in a multiple choice test, for the final assessment of the computer aided design course [3], for the CAD package SolidWorks.

#### 4. EXAMPLE OF MULTIPLE CHOICE TEST FOR CAD EVALUATION

The test contains 15 problems that assess the degree to which students have mastered basic features for 3D part modeling and 2D drawings with SolidWorks. For each problem the student can receive a maximum of 10 points. The professor decides the score for a given problem after checking the 3D model or the drawings made by student and also the response marked on the test.

Some of the issues contained in the multiple choice test are presented as follows.

##### Problem number 1:

In Figure 1 are given several views of a part. Create the solid model of the part and measure on it the dimension noted with X. Point the correct answer from the following four variants: a)  $X = 43.3015$ ; b)  $X = 43.3013$ ; c)  $X = 43.3011$ ; d)  $X = 43.2999$ .

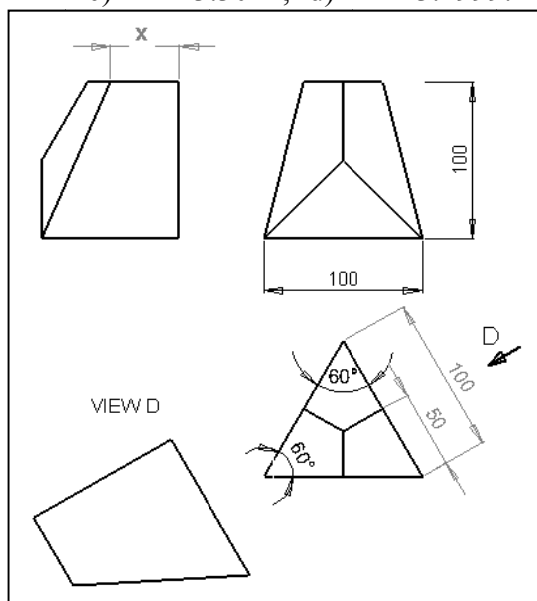


Fig. 1 Part views for Problem number 1

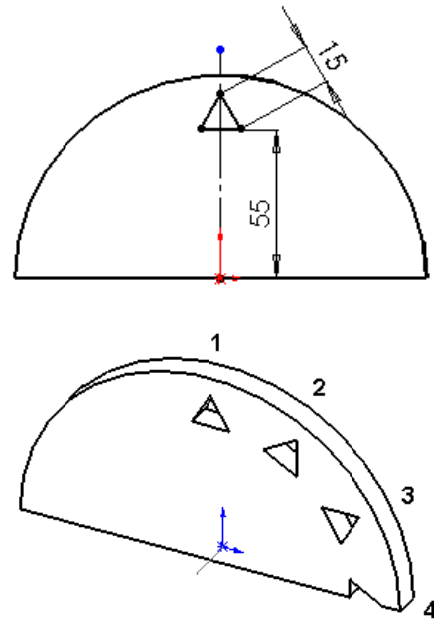


Fig.2 Sketch and part for Problem number 2

##### Problem number 2:

Starting from the sketch in Figure 2, create a semi-circular plate, having the radius of 75 mm and the thickness of 10 mm.

Cut an equilateral triangle of side 15 mm, positioned on the plate surface as in Figure 2. Make a circular pattern to obtain four triangular cuts. Associate the following material to the part: Alloy Steel, with a density of 7700 kg / m<sup>3</sup>. Specify the mass of the plate, by choosing from the following values:

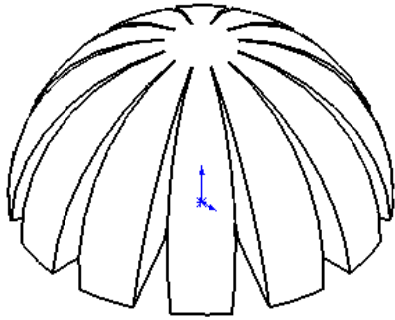
- a) 654.0942 gr, b) 654.0943 gr,
- c) 654.0944 gr, d) 654.0945 gr.

Observation: Since the difference between the possible answers is at the fourth decimal place, it is hard for students to deduce the right answer without making the correct 3D model of the part.

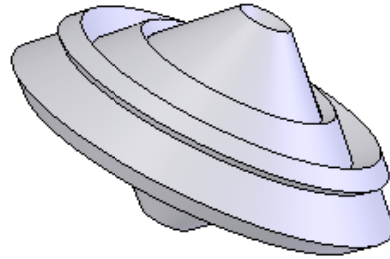
##### Problem number 3:

Indicate which of the following images (noted a, b, c, d in Figure 4) represents the Bottom View of the part presented in Figure 3 in Isometric orientation. Take into account the indication in Figure 5 for part modeling.

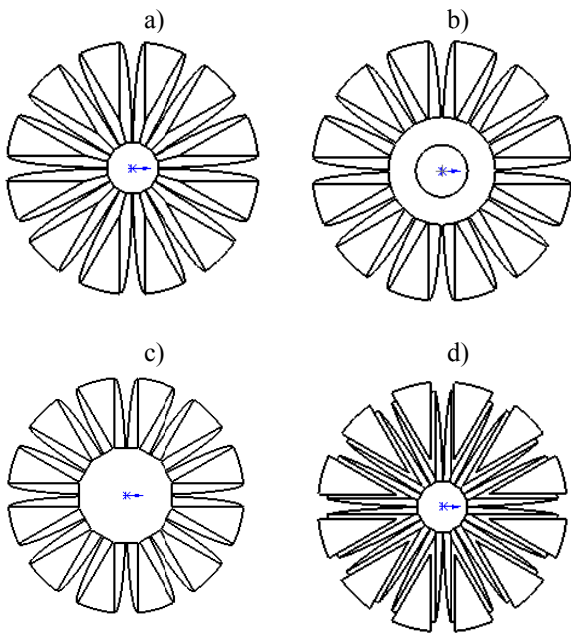
The base shape is a hemisphere of radius 50mm. In a vertical plane, tangential to the hemisphere, sketch an isosceles triangle, having the base of 10mm and the height of 50mm. Starting from the sketch in Plane 1, apply Extrude Cut through 40mm and then a circular pattern to obtain 12 cuts.



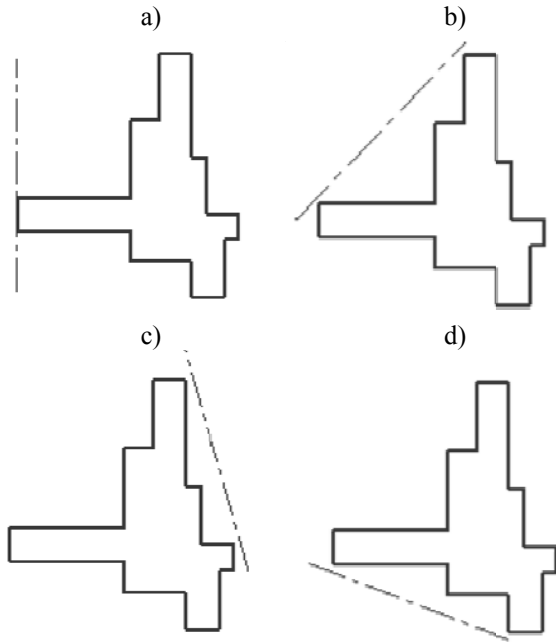
**Fig.3** Problem number 3: Isometric orientation of the part



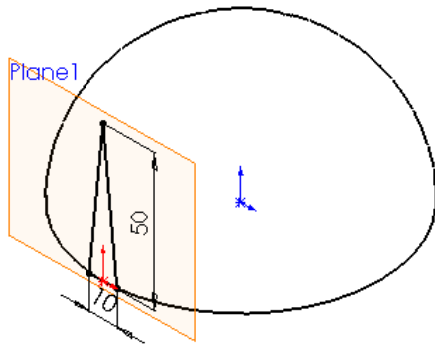
**Fig.6** The 3D model of the part for Problem number 4



**Fig.4** Problem number 3:  
Variants for the Bottom View



**Fig.7** Problem number 4: Variants for the base sketch



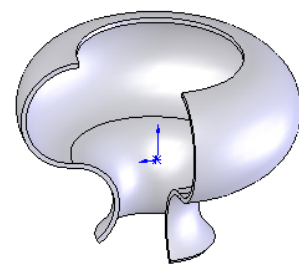
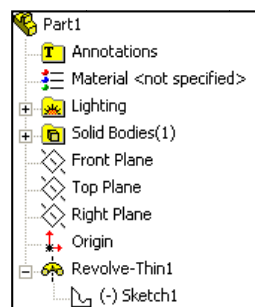
**Fig.5** Problem number 3: Indication for part modelling

**Problem number 4:**

Choose the right sketch used by Revolved Boss/Base feature to obtain the part in Figure 6. Variants are given in Figure 7.

**Problem number 5:**

During the modelling of the part in Figure 8 with SolidWorks, the presented Feature Manager Design tree was created.

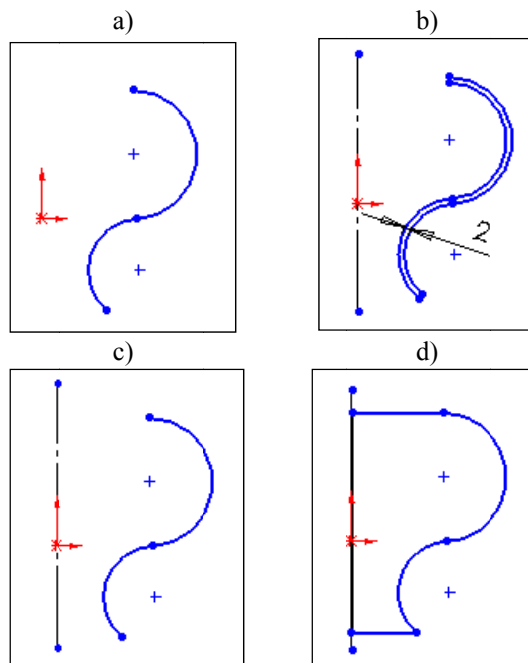


**Fig.8** Feature Manager Design Tree and Part for Problem number 5

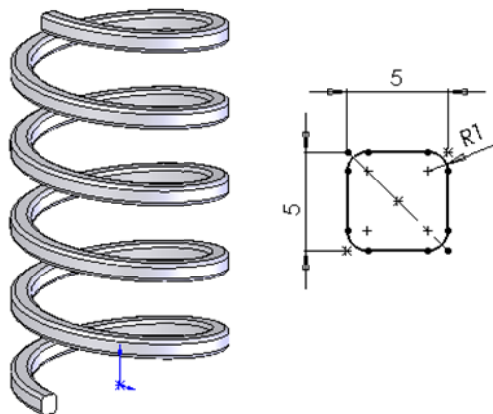
Specify which of the sketches in Figure 9 (a, b, c or d) is named Sketch1 in the Feature Manager Design Tree.

**Problem number 6:**

Make the 3D model of the wire spring in Figure 10, having a rounded edge square section of the wire as dimensioned in the figure.



**Fig.9** Problem number 5: Variants for Sketch1



**Fig.10** Problem number 6: Wire spring and wire section

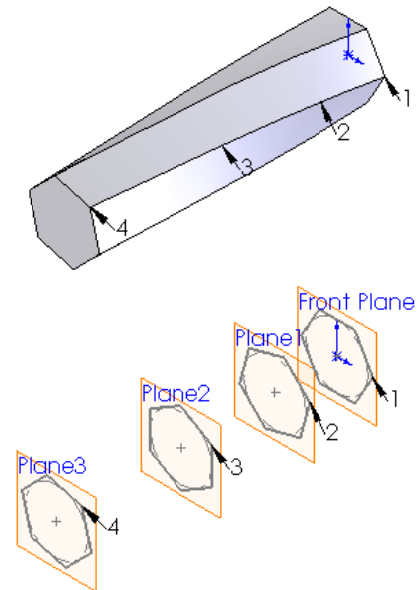
The wire spring has the following characteristics: the medium diameter of the coil = 50mm, the step = 20mm, number of coils = 5, start angle = 0°, direction = clockwise.

Specify which of the following values is equal to the volume of the wire spring:

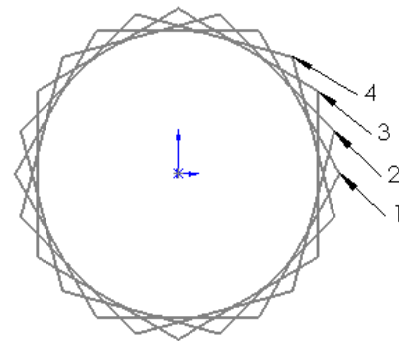
- a) 18960.7670 mm<sup>3</sup>, b) 18960.7675 mm<sup>3</sup>,  
c) 18961.7700 mm<sup>3</sup>, d) 18960.6772 mm<sup>3</sup>.

#### Problem number 7:

Create the model of the part in Figure 11, based on four sketches made in the Front Plane and in other three planes, noted Plane1, Plane2 and Plane3, parallel to the frontal plane and spaced from it with: 20mm, 50mm and 90mm respectively.



**Fig.11** Problem number 7: Part and construction sketches



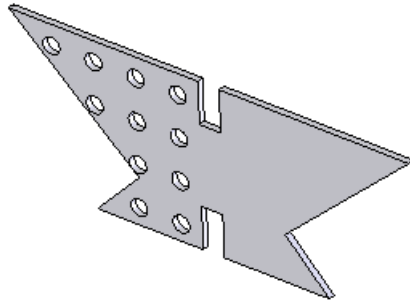
**Fig.12** Problem number 7: Front view of the hexagons of planes: Front, Plane1, Plane2 and Plane3

The sketches from Front Plane, Plane1, Plane2 and Plane3 are hexagons, one rotated from the other with an angle of 15°, as shown in Figure 12. The hexagons are circumscribed by circles with diameters of 20 mm. Specify which of the values below gives the coordinates of the mass centre (mm) of the lofted part:

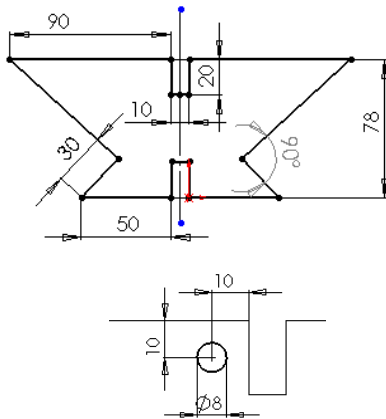
- a) X = 0.0000 Y = 0.0000 Z = 44.9801  
b) X = 0.0000 Y = 0.0000 Z = 44.9727  
c) X = 0.0000 Y = 0.0000 Z = 44.9723  
d) X = 0.0000 Y = 0.1293 Z = 44.9727

#### Problem number 8:

Shape the solid model of the sheet metal part in Figure 13, starting from the sketch given in Figure 14 and considering a thickness of 3mm. Cut a hole of 8mm diameter, positioned on the part as shown in the detail sketch and multiply the hole on horizontal and vertical directions.



**Fig.13** Problem number 8: Sheet metal part



**Fig.14** Problem number 8: Construction sketches

Configure the linear pattern as follows: 15mm on horizontal and 14mm on vertical direction. Skip the holes which are not inside the part borders or intersect them. Indicate how many holes are made in the part:

a) 11    b) 13    c) 15    d) 16

## 5. CONCLUSIONS

Assessment is an important component of the learning process, which can measure its effectiveness. In computer aided design courses, the testing of knowledge and skills acquired by students takes a specific feature,

### Modelarea asistată de calculator predată studenților în inginerie

Exprimarea ideilor prin intermediul imaginilor grafice este principala modalitate de comunicare utilizată în inginerie. Orice proiect ingineresc cuprinde o parte desenată, iar în ultimii ani modelarea asistată de calculator a luat locul desenului la planșetă, datorită multiplelor beneficii pe care le aduce. În ingineria mecanică cele mai preferate sunt soft-urile de modelare a solidelor. Lucrarea de față aduce în discuție câteva idei legate de creșterea eficienței în predarea și învățarea tehnicilor de proiectare asistată de calculator, cu accent pe prezentarea unor metode de evaluare și exemple practice de evaluare pe bază de test grilă.

centered on a given software package. The professor should pay special attention to the test development, so it has to be gradual, to allow objective assessment, to decrease the likelihood of cheating and to increase students' motivation and satisfaction within the course. The assessment results will provide feedback for the educational work and will allow the improvement of the teaching methods and course content.

The application of multiple choice tests to assess knowledge acquired in the case of computer aided design discipline demonstrated the following advantages: - Allows checking a wide range of knowledge and skills; - Avoids blocking during the test; - Emphasizes the accuracy of the developed computer model; - Reduces the risk of fraud during examination; - Can be easily changed and adapted for several groups of students.

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