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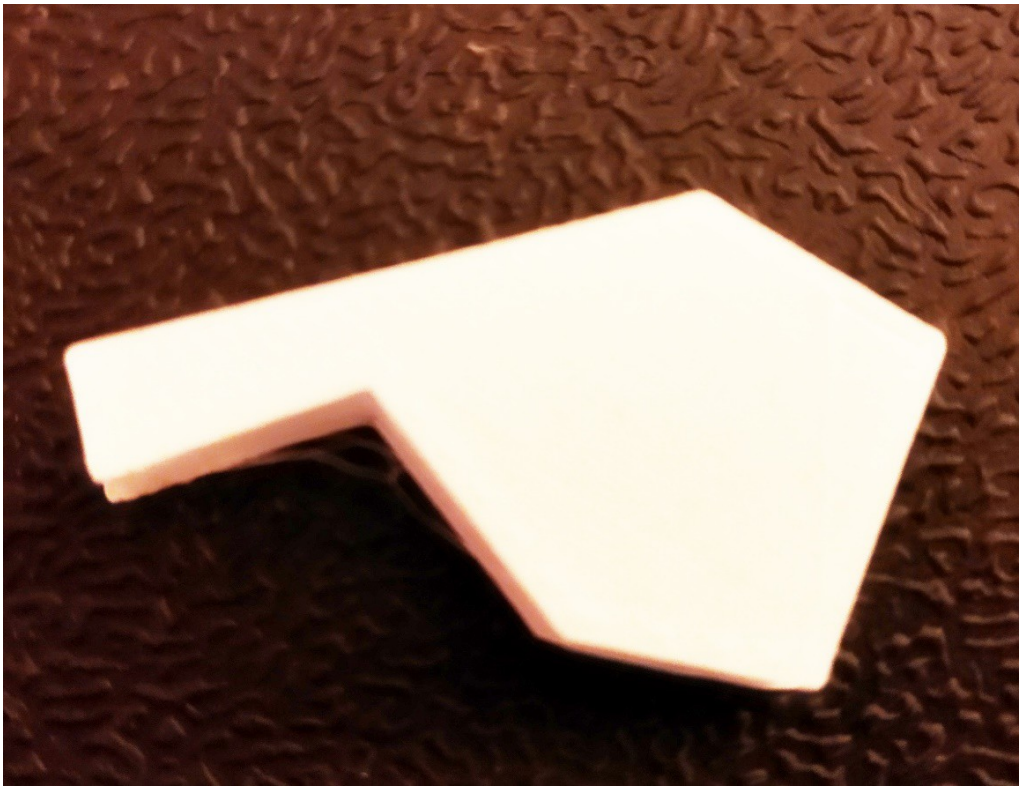
SCHOOL

DRAWING A WHISTLE WITH AUTOCAD and 3D printing



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Month year : May 2022

Course summary

In this course, students of the compulsory education school learn the basic commands and drawing techniques in a CAD environment. Acquiring knowledge about a typical drawing technique in a CAD software, in order to create a 3D object from a 2D design (extrude command). Learn to use elementary knowledge of geometry and mathematics connecting with drawing (Straight line, coordinate axes, the z axis).

Course facts in brief

Time: 4x45 min

Number of pupils: 55

Number of supervisors: 6

Number of groups: 4

Age of pupils: 12+

Prerequisites for students: A review at some geometrical terms and definitions (coordinate system, x,y,z coordinates etc)

Prerequisites for supervisors: Learn AutoCad simple commands in order to be able to draw the 3D whistle**,** learned about “slicer” program 3D printing.

Disclaimer

Table of Contents

Introduction

Background

Society's and business's need for people with technical knowledge is increasing, at the same time as the interest in applying for technical education is decreasing or at least not increasing to a sufficient extent. Something should therefore be done so that more young people will choose technical both vocational and pre-school education in upper secondary school.

Purpose

The purpose of these lessons is to allow younger students in compulsory education school to come into contact with interesting technology they have not worked with before, while they are supervised by older students who attend vocational technical high school. The older students become a bit of a role models and they can more easily transfer their youthful enthusiasm, interests and attitude over technology to the younger students.

Method

The younger students are given the task of solving a technical problem, for example to program a Lego robot, construct a game in CAD and print it on a 3D printer or to mill the game in the workshop together with high school students based on the drawing they created in CAD. To succeed in this, the older students must teach and supervise the younger students the current technology. The contact between the younger and older students around concrete tasks can create conditions for both arousing and deepening interest in technology.

DRAWING A WHISTLE WITH AUTOCAD and 3D printing

Preparations in high school

The high school students have taken AutoCad courses and especially the steps and the technique of how we can draw a 3-dimensional object using this software This object is a whistle, and they had a template for the outline shape. This simplified more the process of drawing and gives a note of a game to it. They have also learned about the limits which exist in 3D drawing when the drawing is for 3D printing.

Finally, they learned to use a"slicer" software in order to convert the 3D object to a 3D printable file and print it out.

Template of the outline of the whistle

Preparations in primary school

The only preparations in compulsory school was to find suitable dates for the courses So, after communication between the compulsory and high school there were set 2 visits in the compulsory school, in class A, (A1,A2,A3 classes) and in class B, (B1,B2, B3classes) , each class had 12-15 students. The number of the supervisor students were 2 at each class. Also, the 3D printer was carried to the compulsory school for the 3D printings.

Implementation

The high school students went to the compulsory school carried with them the 3D printer and met with the younger students' classes and with their teachers. They taught and supervised totally 55 students in various classes. In 2 classes there was the capability for the younger pupils to sit in front of a PC per pair, so they simultaneously follow every step of the high school's students in drawing the whistle using the AutoCad.

After completed the drawing, the younger pupils under the supervision of the high school's students made use of the 3D printer in order to print the whistle.

Evaluation

When the students have attended the courses, an evaluation is made of how they experienced the CAD course and the 3printing implementation and of how their teachers felt that the course worked for the students. The purpose is to get tips on how we can improve future courses. Supervisors should also be allowed to evaluate their participation. The evaluation is done with the help of the tool Google Form.

Appendix

3D MODEL DESIGN USING AUTO CAD

❖ OBJECTIVES

•Gain an overview of how-to use of α CAD program to draw a 3D model for 3D printing.
•Use of α CAD software to draw a 3D model for printing.

❖ LEARNING OUTCOMES

KNOWLEDGE

- Gain knowledge about designing with AutoCad software.
- Acquiring knowledge of the basic commands and drawing techniques in a CAD environment.
- Acquiring knowledge about a typical drawing technique in CAD software, in order to create a 3D object from a 2D design (extrude command).
- Incorporation of elementary knowledge of geometry and mathematics. (Straight line, coordinate axes, the z axis).

Competence

✓ Gain skills to be able to design a simple 3D object in AutoCad with a specific step-by-step drawing technique.

❖ RECOMMENDED TRAINING METHODS

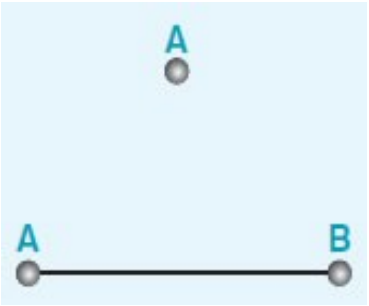
- Interactive theory.
- Examples.
- Object design.

➢ WHISTLE DESIGN

A FEW MATHEMATICS AND GEOMETRY.

Line segment

Let's remember a bit about Geometry. What is a line segment? It is that geometric figure contained between two points A and B of a *straight line e. A stretched thread with ends A and B gives us an image of the concept of line segment AB. Points A and B are the endpoints of the line segment. We say that the points A and B define the line segment AB.

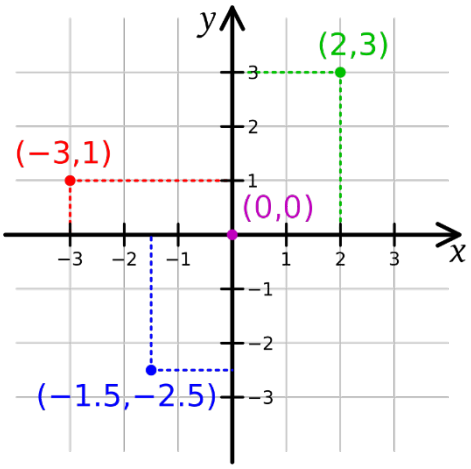


(*A(straight) **line** is a line of infinite length and zero thickness, without beginning and end and absolutely straight. The relationship that connects the points belonging to a straight line is described in the plane of Cartesian coordinates by a first degree equation Ax+By +Γ=0, where at least one of A and B is different from 0).

Cartesian coordinate system

In mathematics, the Cartesian coordinate system is a rectangular coordinate system used to specify a point in the plane or space.

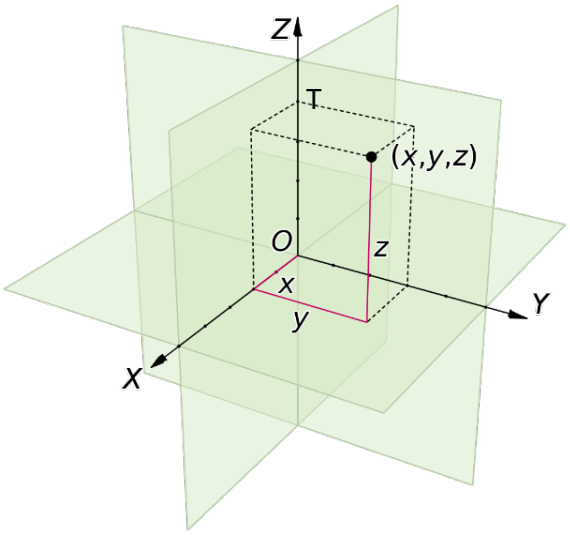
The Cartesian coordinate system in the plane consists of two oriented straight lines, perpendicular to each other, which are conventionally called the abscissa axis (horizontal axis) and axis ordinates (vertical axis) and denoted respectively **with x and y.**



The point where they are intersected is called the **origin of the coordinate system**. A point on the Cartesian plane is uniquely identified by a pair of these numbers, the abscissa and the ordinate.

The abscissa is the distance of the point from the y-axis and the ordinate is the distance of the point from the x-axis. The abscissa and ordinate are the coordinates of the point. By this convention, the origin of the axes coincides with the point (0,0).

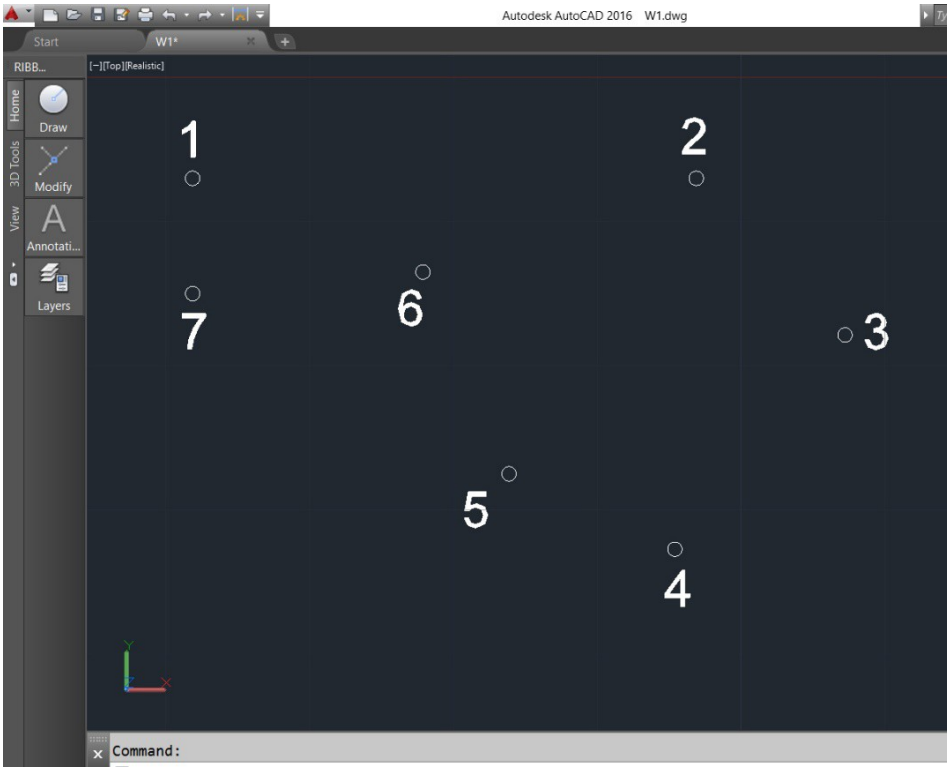
In the t**hree dimensions**, in addition to the x and y axes, we also define a third z axis, perpendicular to the plane defined by the first two. Thus each point in space can be represented by a unique trinity of numbers (x,y,z), with each coordinate to corresponds to the vertical distance of the point from each of the three axes respectively.



What is a CAD program?
CAD stands for Computer-Aided Design and is the use of computers (or workstations) to help create, modify, analyze or optimize a design.

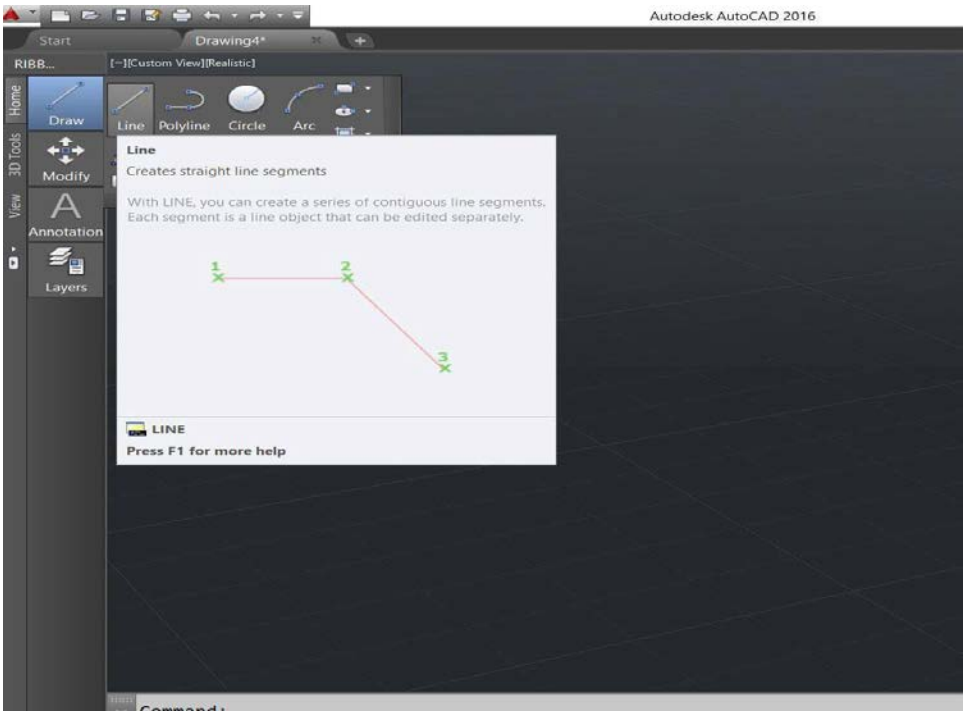
➢ **STEP 1 : We draw the 2-D outline of the whistle in AutoCad.**

To draw various geometric objects in AutoCad, we select a command/tool and then follow a specific execution path.
*T**o simplify the process of drawing the outline of the whistle, 7 circles were drawn, which with the help of the "LINE" command we will join their centers and the flat, 2-dimensional outline of the object will be formed. (CLICK HERE TO OPEN THE FILE TO START DRAWING)**
***AutoCad software must be installed to open**

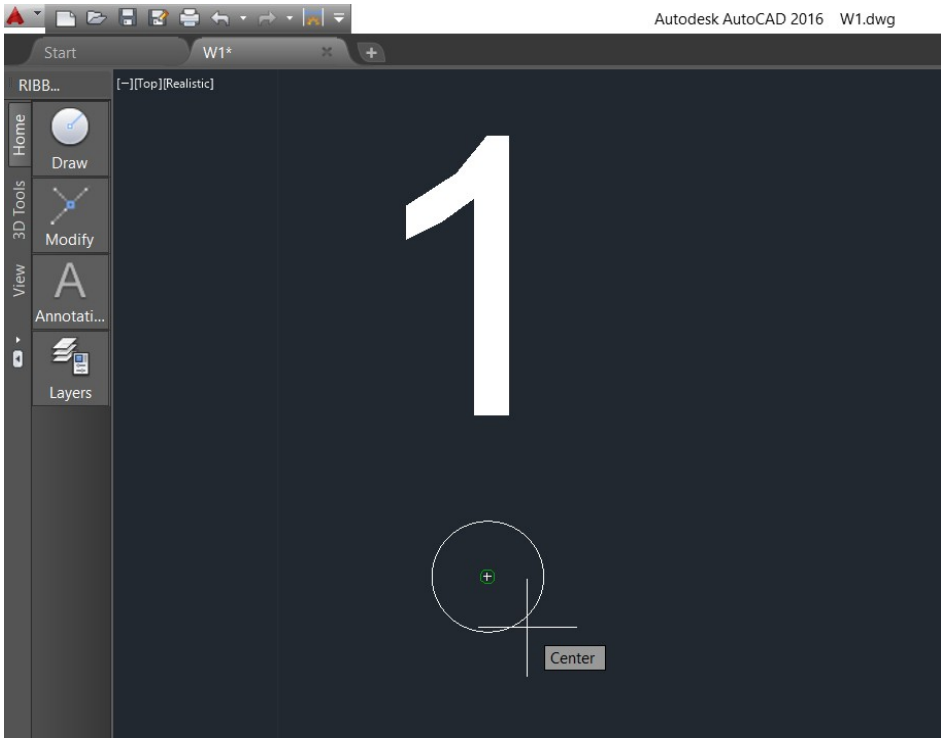


- The "**LINE**" command

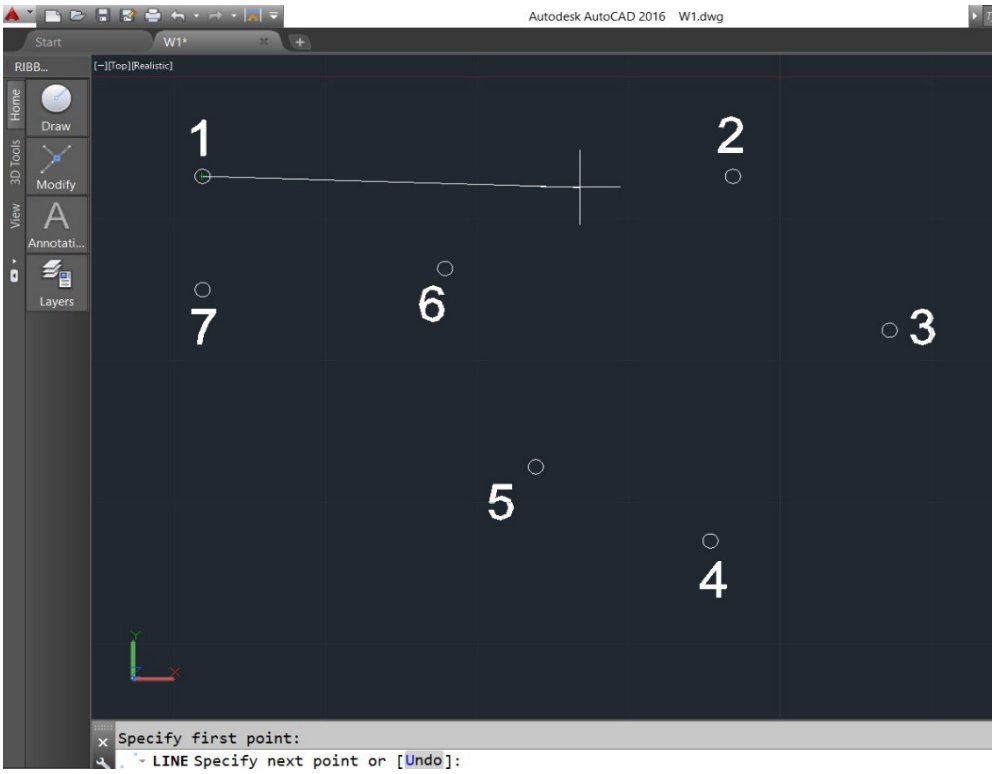
We select the "**LINE**" command: tab "**HOME**" ⟶ "**DRAW**" ⟶ "**LINE**".

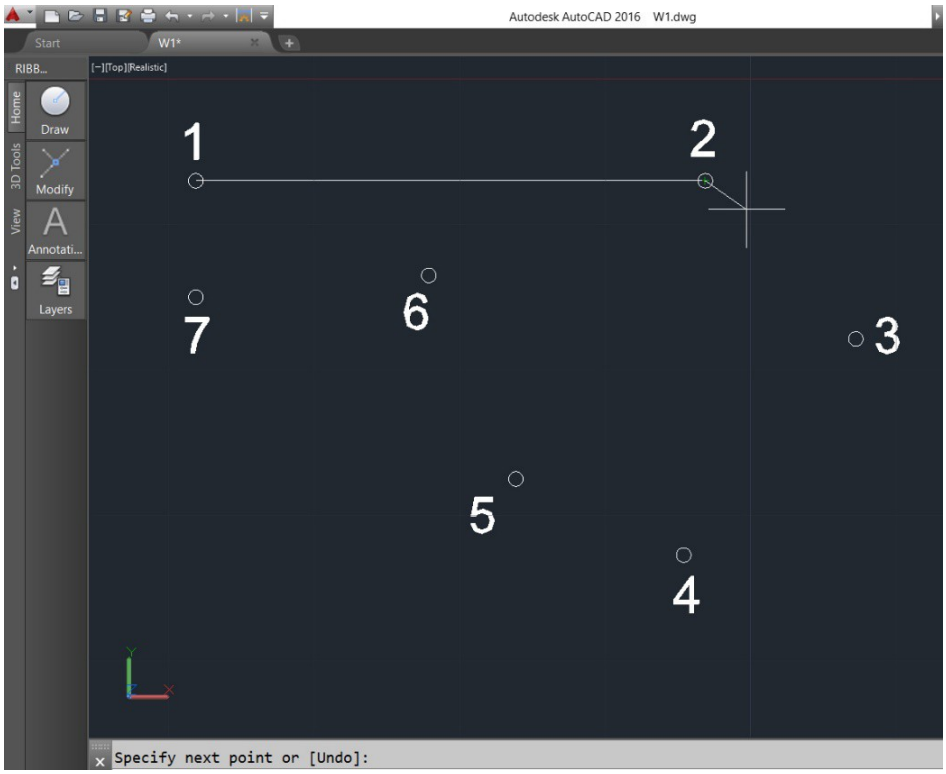


As we mentioned before, to draw a straight line, we need **2 points**, a start and an end. So here, when at **the command line** prompts to select the 1st point: We press "click" in the center of circle 1 and then, in the prompt to select the 2nd point we "click" in the center of circle 2. (To **be sure we "click" on the centers of the circles, we "click" when the shape of the "cross +" appears).**



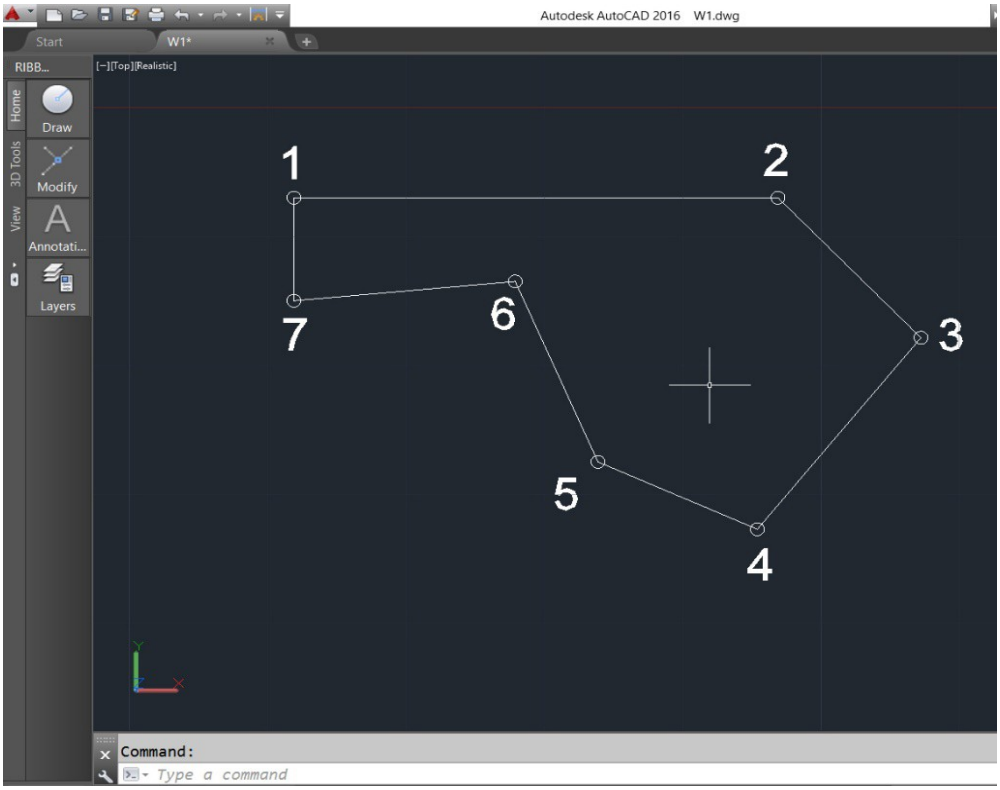
and then, at the prompt to select the 2nd point, we "click" in the center of circle 2.



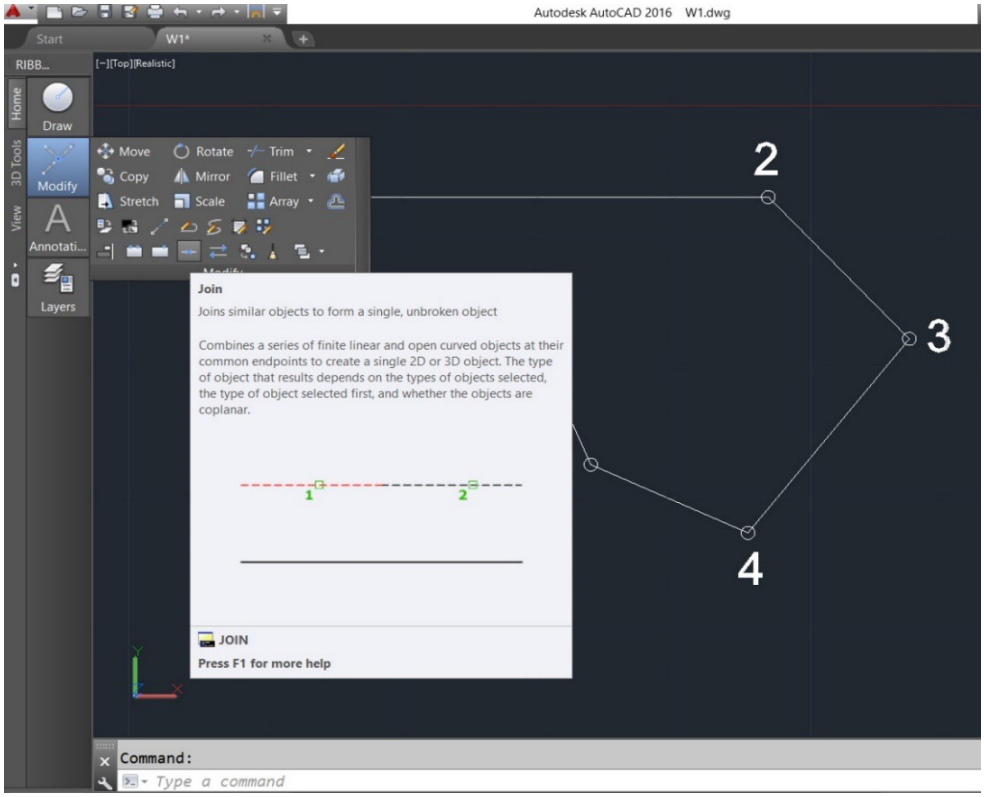


We continue with the "**LINE**" command active, by "clicking" on the centers of the remaining circles 3,4,5,6 and 7 and at the end we press "ENTER" or "ESCAPE".

This is how the final outline of the whistle is formed.



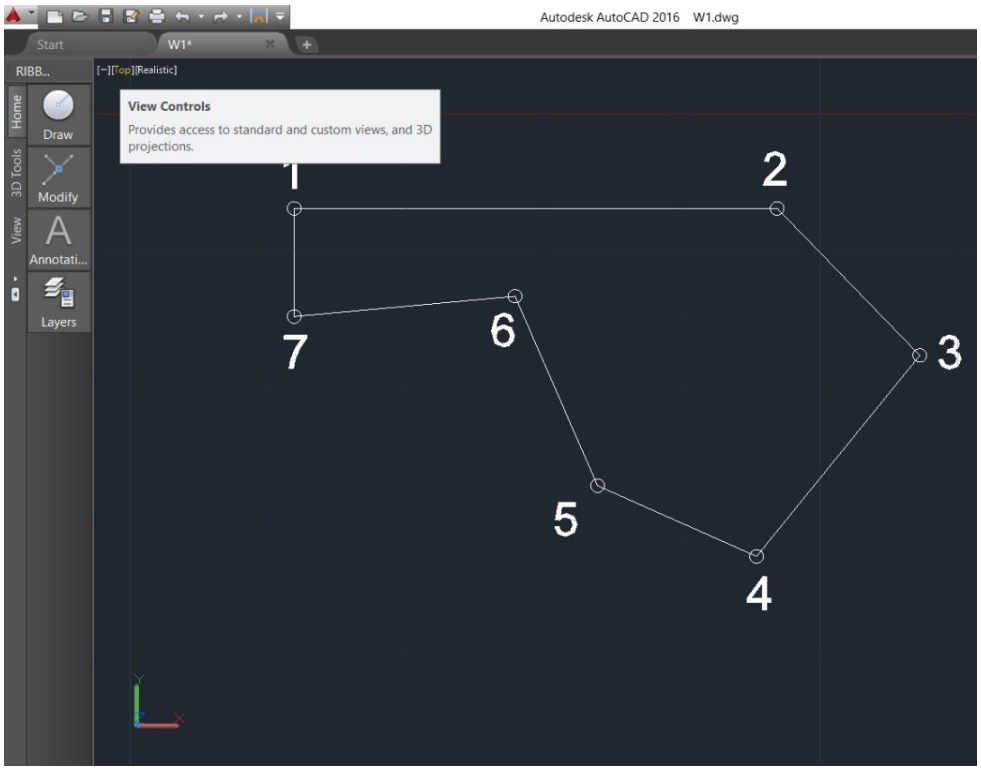
- STEP 2: Join the straight parts of the outline in a continuous closed line. The "**JOIN**" command; "**JOIN** " command: tab "**HOME**" ⟶ "**MODIFY**" ⟶ "**JOIN**".



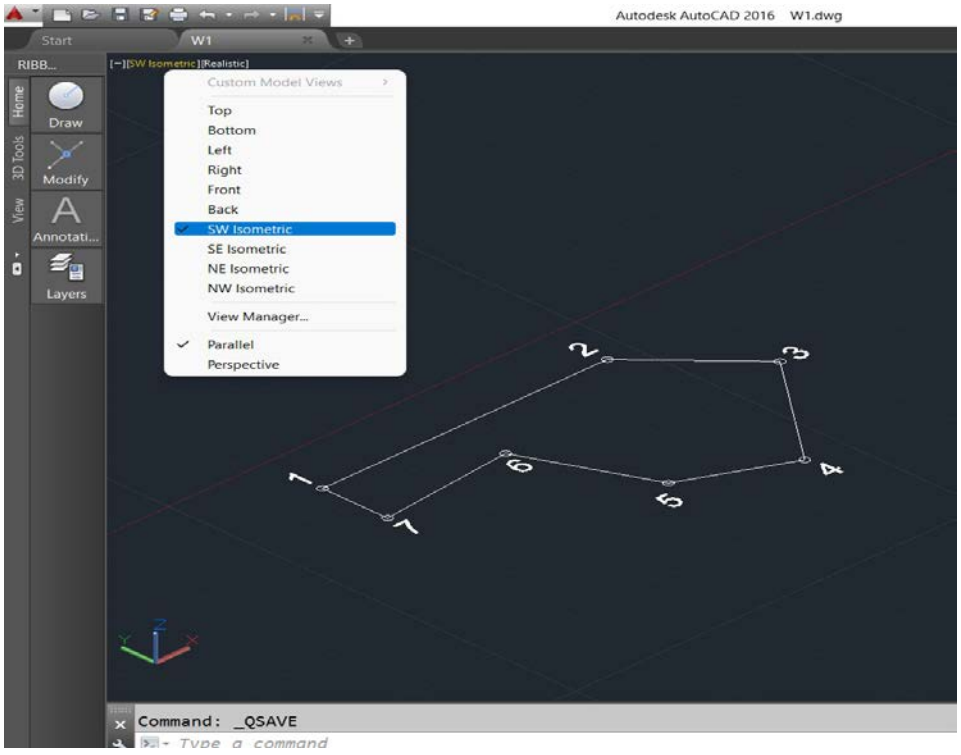
At the "**Select objects to join**" prompt, we select all lines of the outline shape and press "ENTER".

- Changing the View

From the "V**IEW CONTROLS**" menu, we select "I**sometric view**" instead of "TOP VIEW", to change the perspective from which we see the object, from 2 dimensions into 3 dimensions, from the plane into a space view.

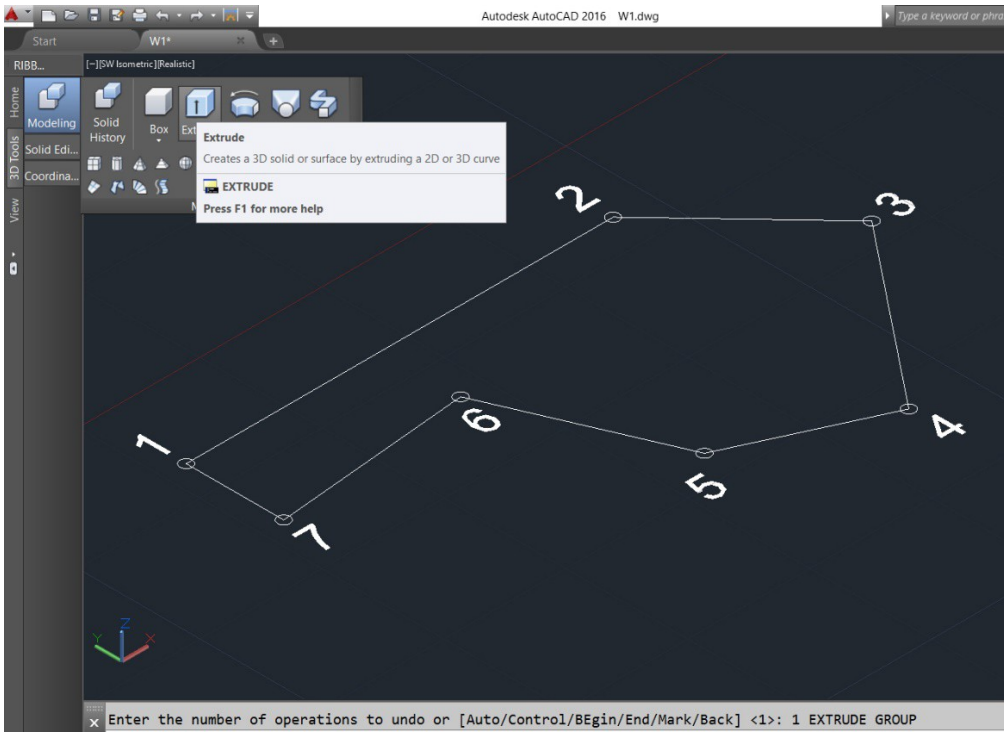


From 2-dimensions (x,y axes) into 3-dimensions (x,y,z axes) .The z-axis makes the difference. In the lower left corner now we can observe the coordinate axes System in 3 dimensions

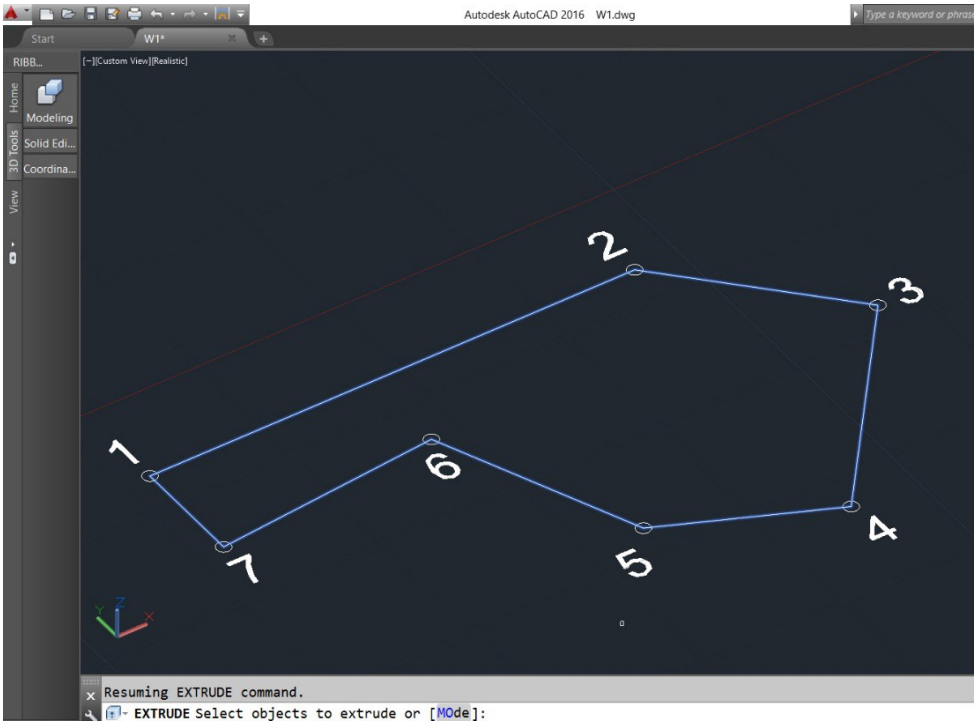


➢ **STEP 3:** From 2-Dimensions to 3-Dimensions

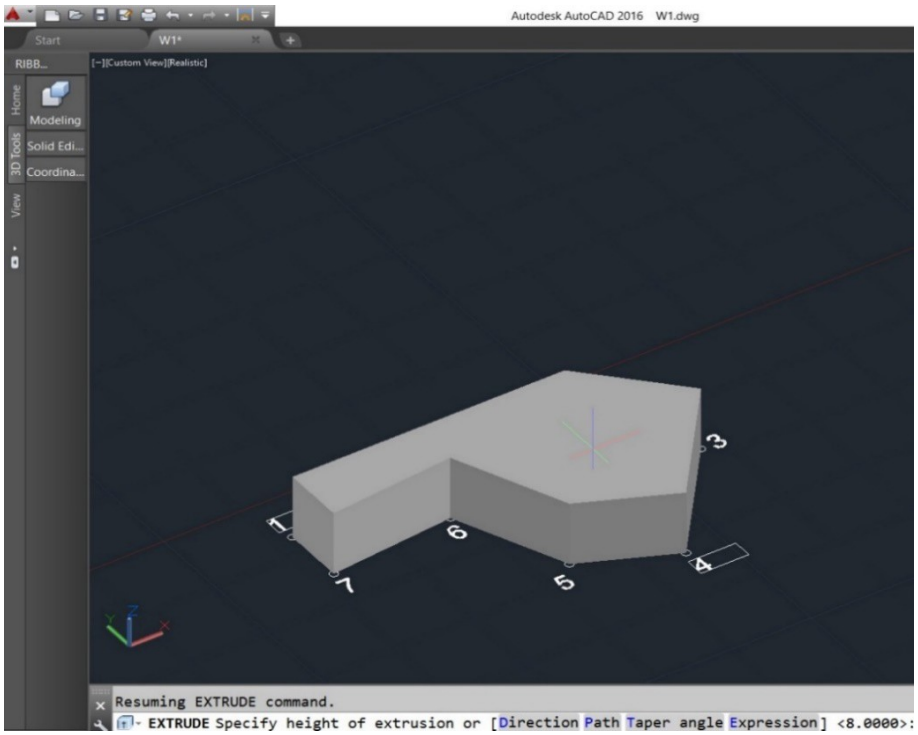
The "**EXTRUDE**" command: we select "**3D TOOLS**" ⟶"**MODELING**"⟶ "**EXTRUDE**"



At the "**Select object to extrude**" prompt, we "**click**" on the object, select it and press "**ENTER**".



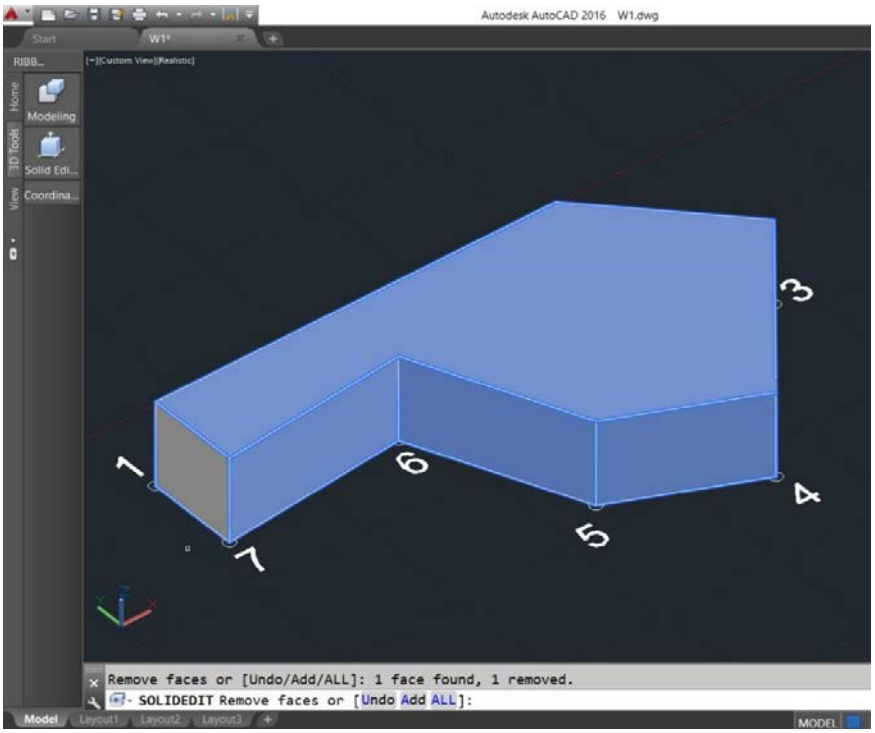
Then, at the "**specify height of extrusion**" prompt, we type **8** and press "**ENTER**" (**This value gives a height to the object equal to 8 units, i.e. z=8 (here mm)**. This way we give the final height to the object.



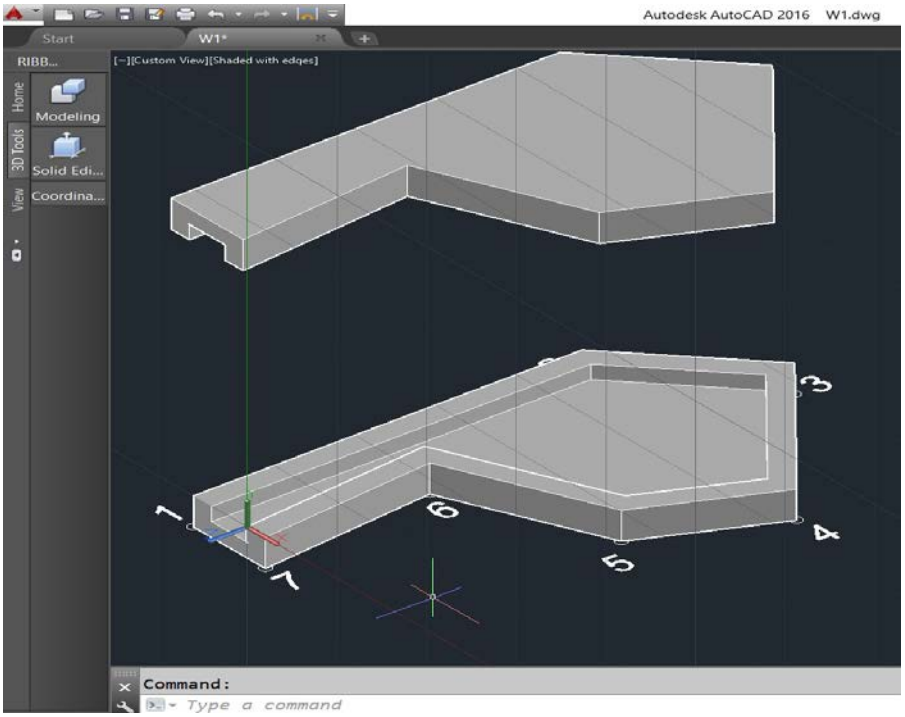
➢ **STEP 4** : Creating the inner hollow space of the whistle.

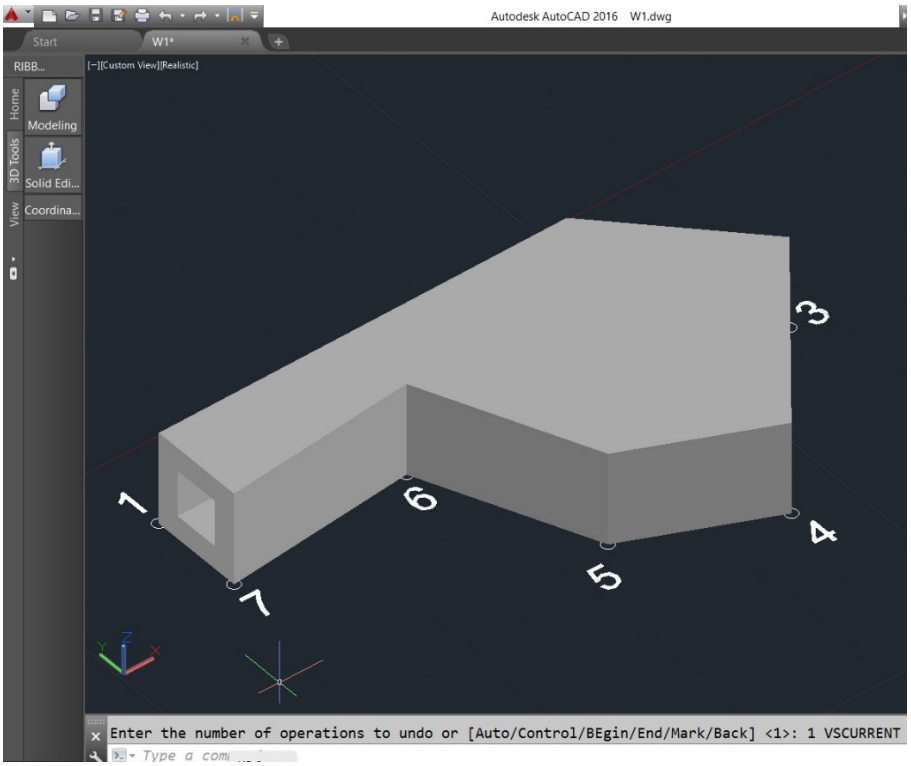
The "**SHELL**" Command Converts a solid into a hollow shell with concrete wall thickness: "**3D TOOLS**" ⇨ "**SOLID EDITING**"⟶"**SHELL**".

At the prompt "**Select a 3D object**", we "**click**" and select our object and then, at the prompt "**remove faces**" we select the square on the front side (**1-7**) and press "**ENTER**".



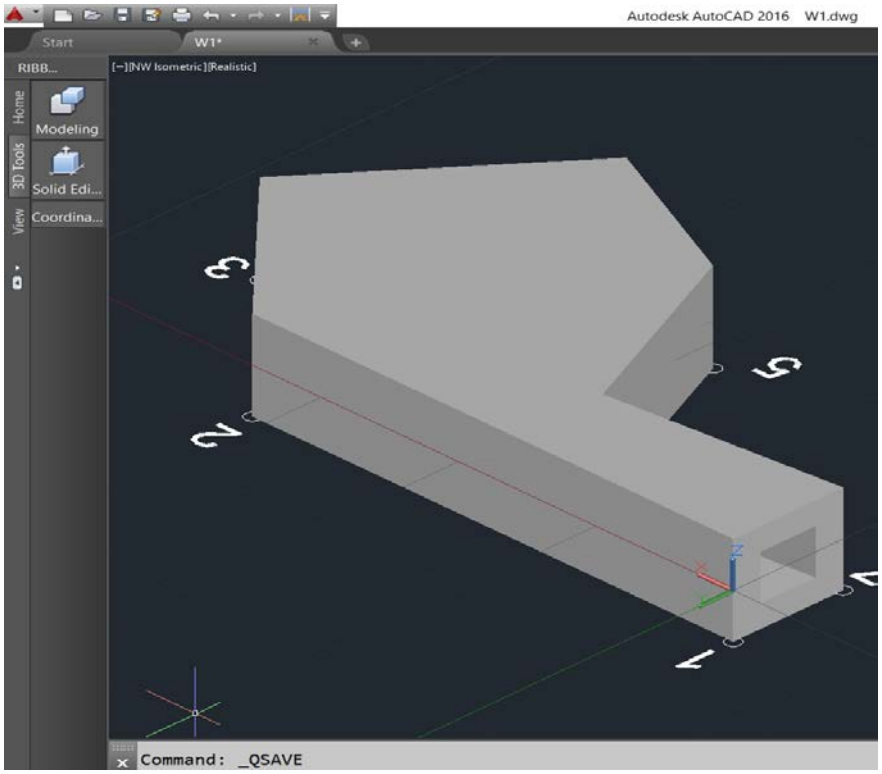
Finally, at the "**Enter the shell offset distance**" prompt, we type **2** and press "**ENTER**" (**this will be the thickness of the wall of the whistle**). This is how to form the internal empty space of the whistle





- **STEP 5: Creating the slot of the whistle.**

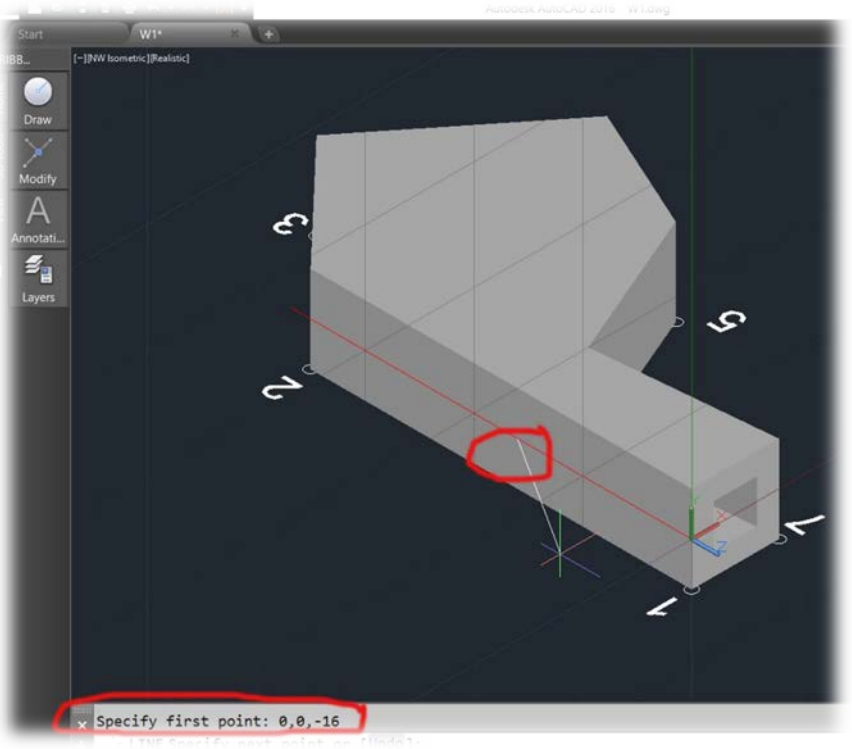
Axis System Transfer: After changing the view of the object, by Right-clicking on the axes and choosing "**ORIGIN**" from the drop-down menu, we transfer the axes to the middle of a vertical edge of the square side between circles 1 and 2:



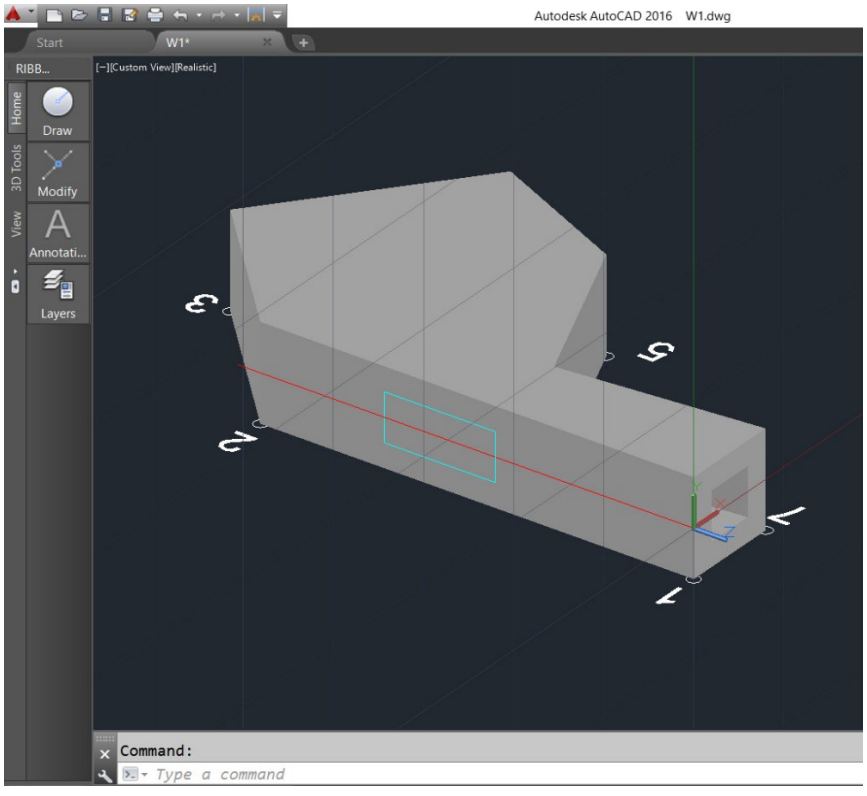
we are going to draw a **rectangular parallelepiped** with the dimensions of the whistles' slot. But first we will draw a rectangular with dimensions **4 x 9.** The first side of it is 16 mm far from the coordinate system.

We will follow again the same procedure from **step 1** to **step 3**, that is, the "**LINE**", "**JOIN**", "**EXTRUDE**" commands, to draw a rectangular parallelepiped with the dimensions of the slot of the whistle.

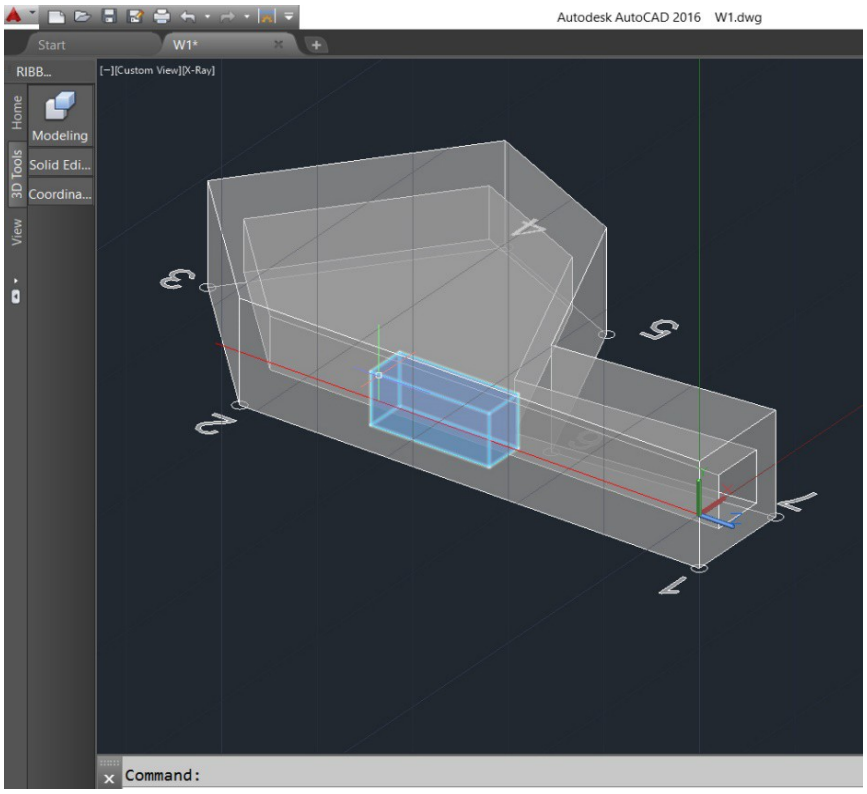
Now we will need the Cartesian coordinates. We select the "**LINE**" command and for the first point we type **0**,**0**, **-16**. In this way we define the starting point of a straight segment with coordinates (**x=0**, **y=0**, **z=-16**). **(*These values can change according to the orientation of the axes**).



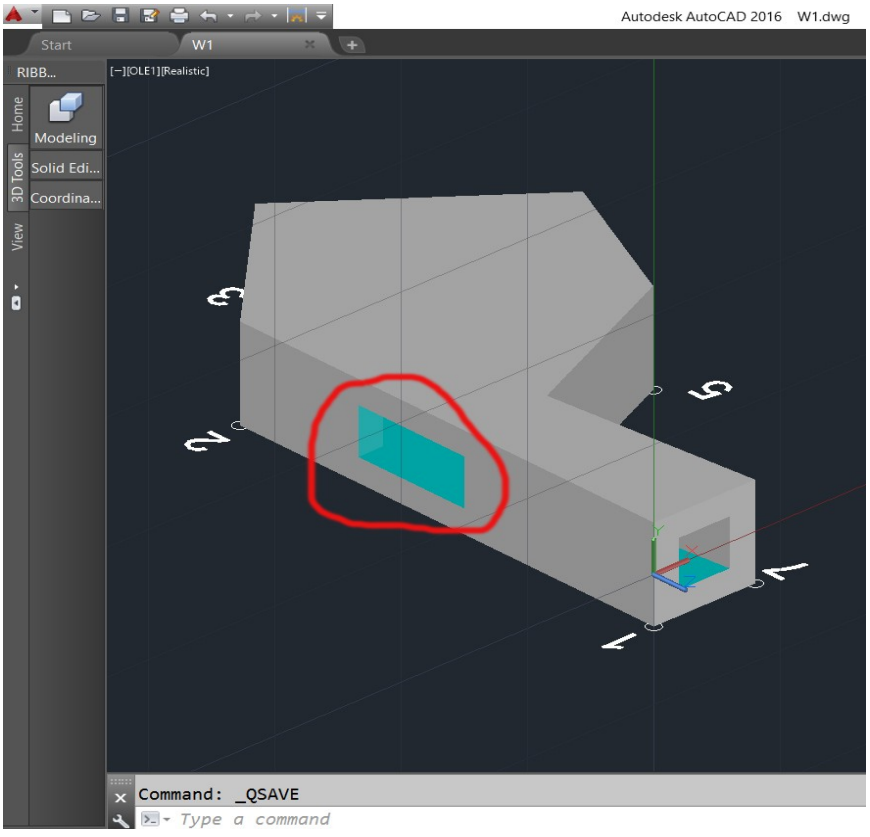
We carry on with the "**LINE**" command, go up vertically and type **2**, then horizontally left and type 9, vertically down and type **4** , horizontally right and type **9** just to draw a rectangular parallelogram with dimensions **length=4** x **9= width.** Then with the " **JOIN** " command we connect all the straight segments of the rectangle into a single closed line.



Then the "**EXTRUDE**" command again: We give a value to **z=-3** and a rectangular parallelepiped is formed with dimensions **length=4, width=9**, **height=3** (4x9x3).



STEP 6: The **"SUBTRACT" command:** This command subtracts a solid from another solid**:** "**3D TOOLS**" ⟶"**SOLID EDITING**" ⟶"**SUBTRACT**": At the prompt "**Select objects**" we select the whistle body and press "**ENTER**". At the second "**Select objects**" prompt we select the rectangular parallelepiped and press "**ENTER**". This is how the slot is created. At this point the whistle designing is completed. But, for whistle's functionality reasons we have to make **two more steps.**



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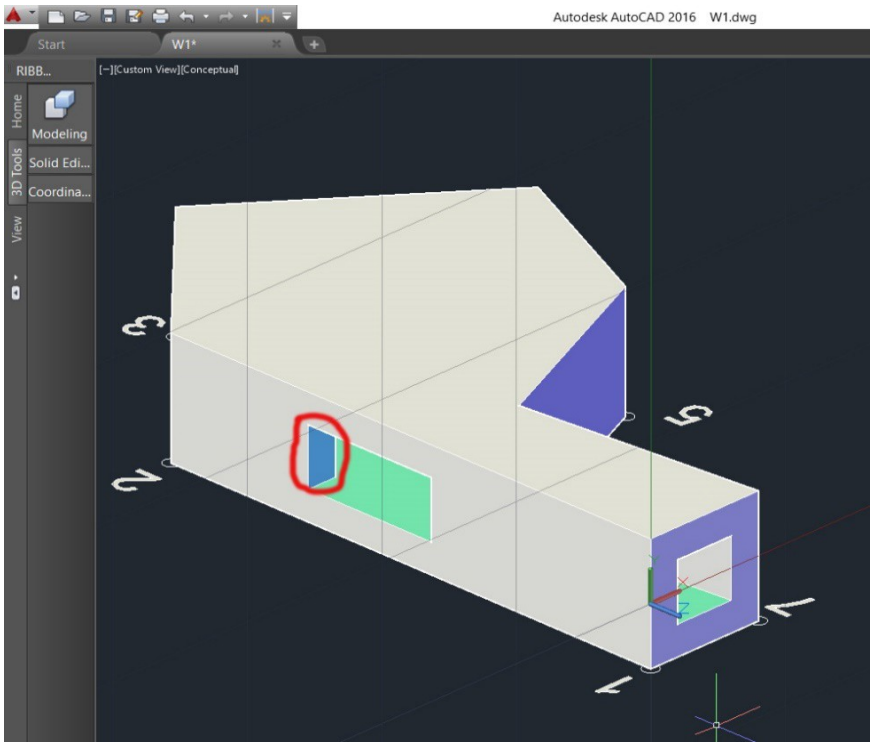
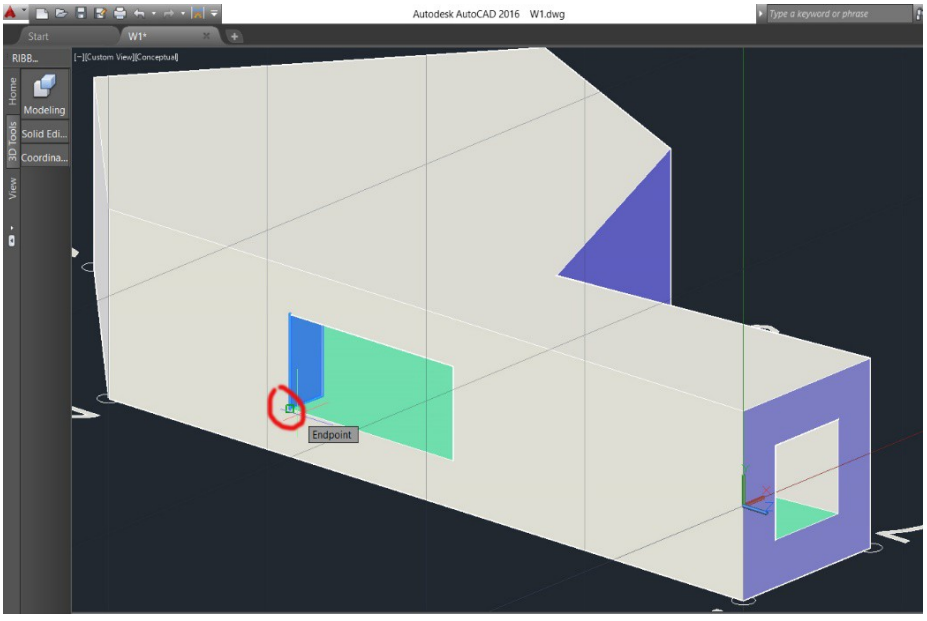
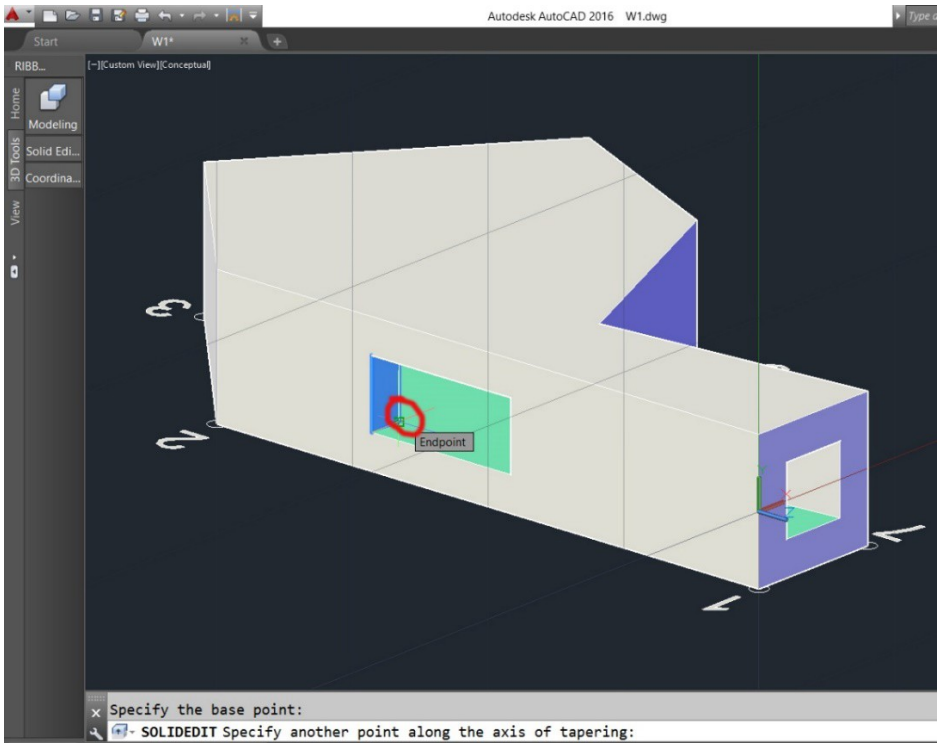
For the functionality of the whistle, we should give a slope to one side of the slot (blue color).



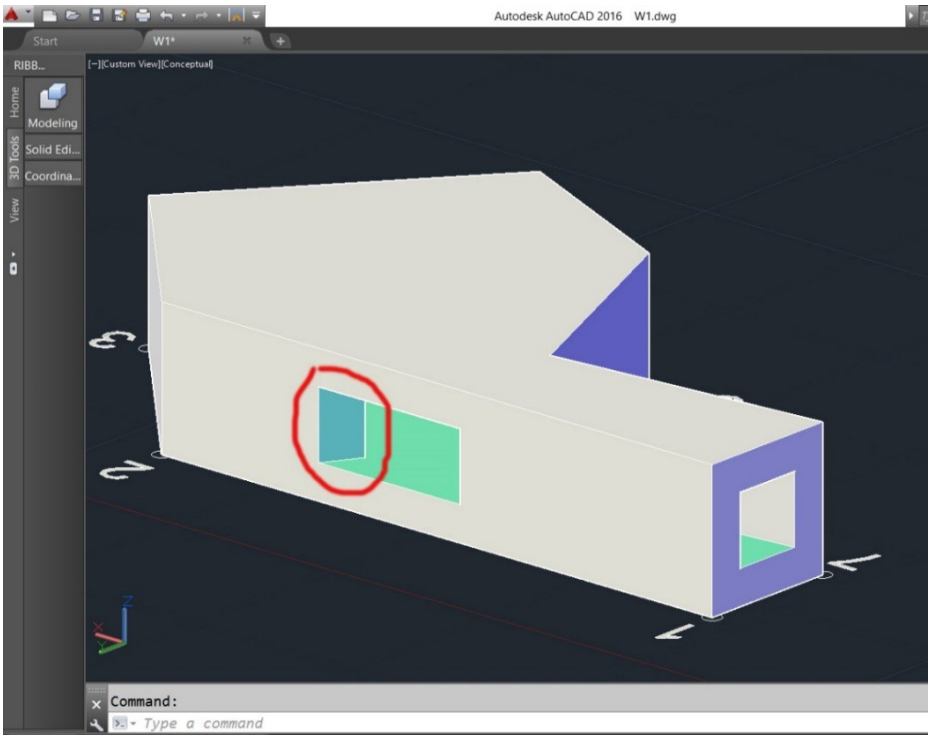
The “**TAPER FACES**” command: We select "**3D TOOLS**" ⟶"**SOLID EDITING**"⟶ "**TAPER FACES**": At the prompt "**select faces**" we select the blue surface and press "**ENTER**", at the prompt "**specify the base point”** we select the point of the bottom left corner of the surface ,



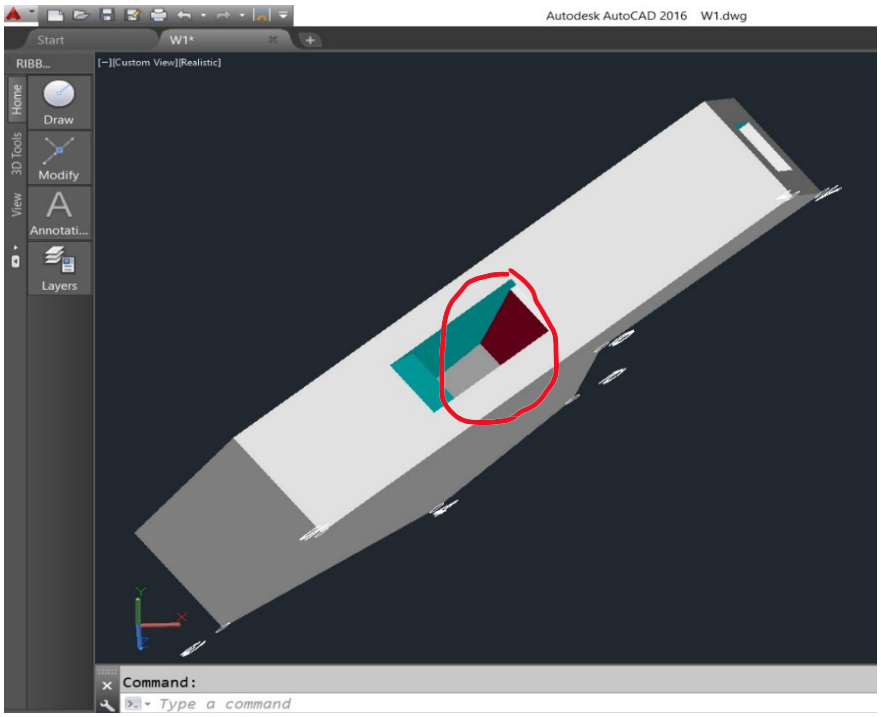
and at the prompt "**specify another point along the axis of tapering**", we select the point of the opposite corner.

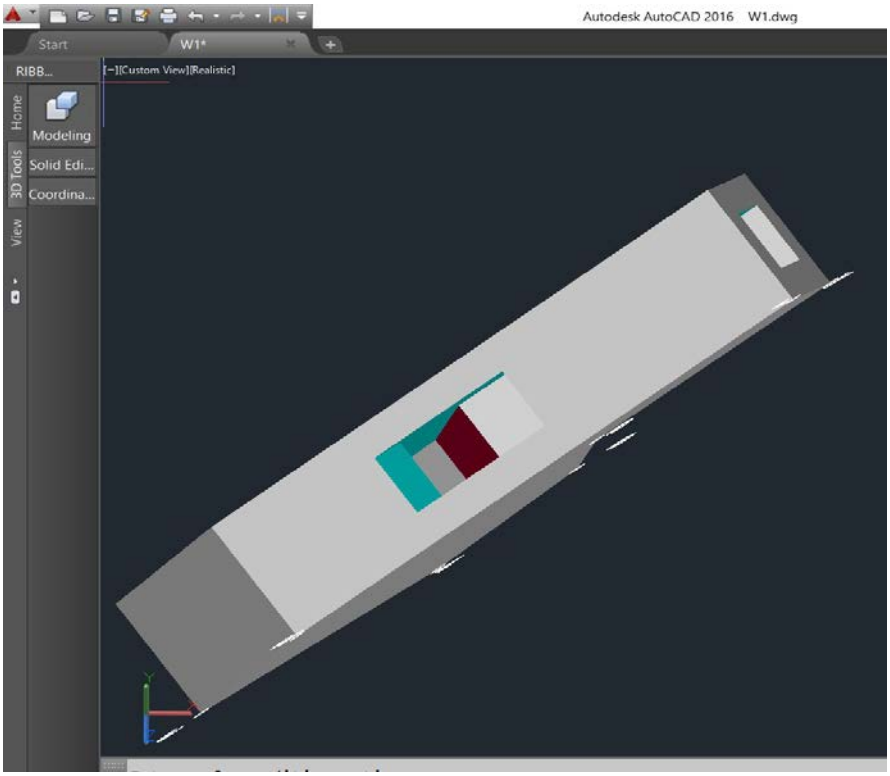


At the "**specify the taper angle**" prompt, we type **-30** and press "**ENTER**". This completes the command that gives the surface a taper angle.

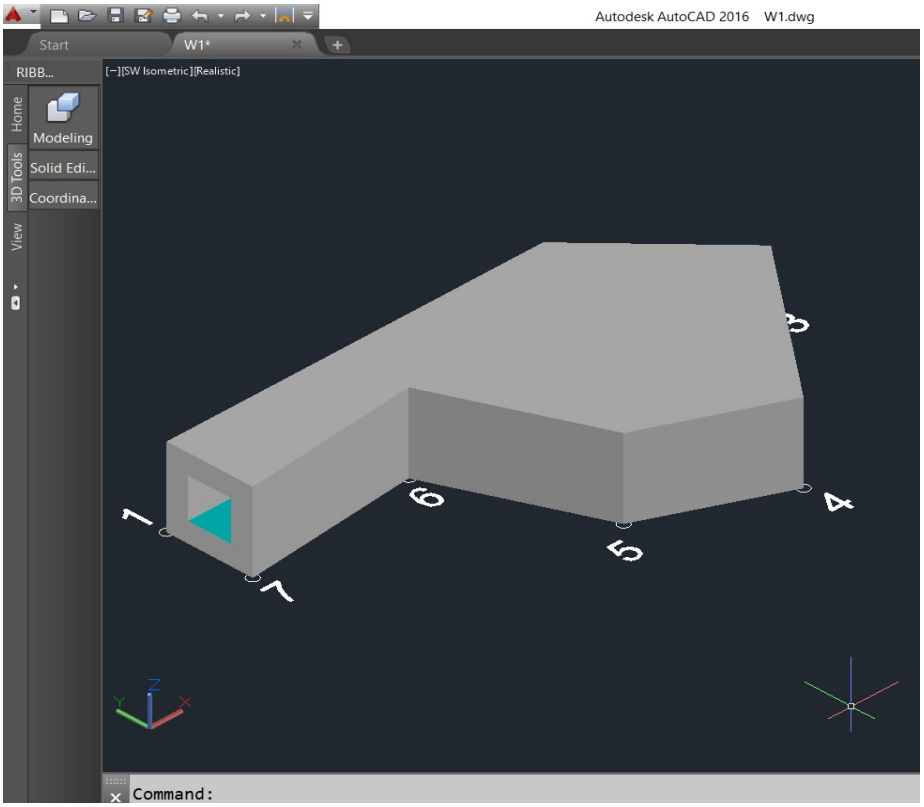


Finally, for whistle's functionality reasons again, we should extend/displace an inner surface (**red surface**). This will be done using the "**Offset faces**" command.
We select "**3D TOOLS**" →"**SOLID EDITING**"→"**Offset faces**". At the "**select faces**" prompt, we select the red surface and press "**ENTER**" and then at the "**specify offset distance**" prompt, we type **2**.

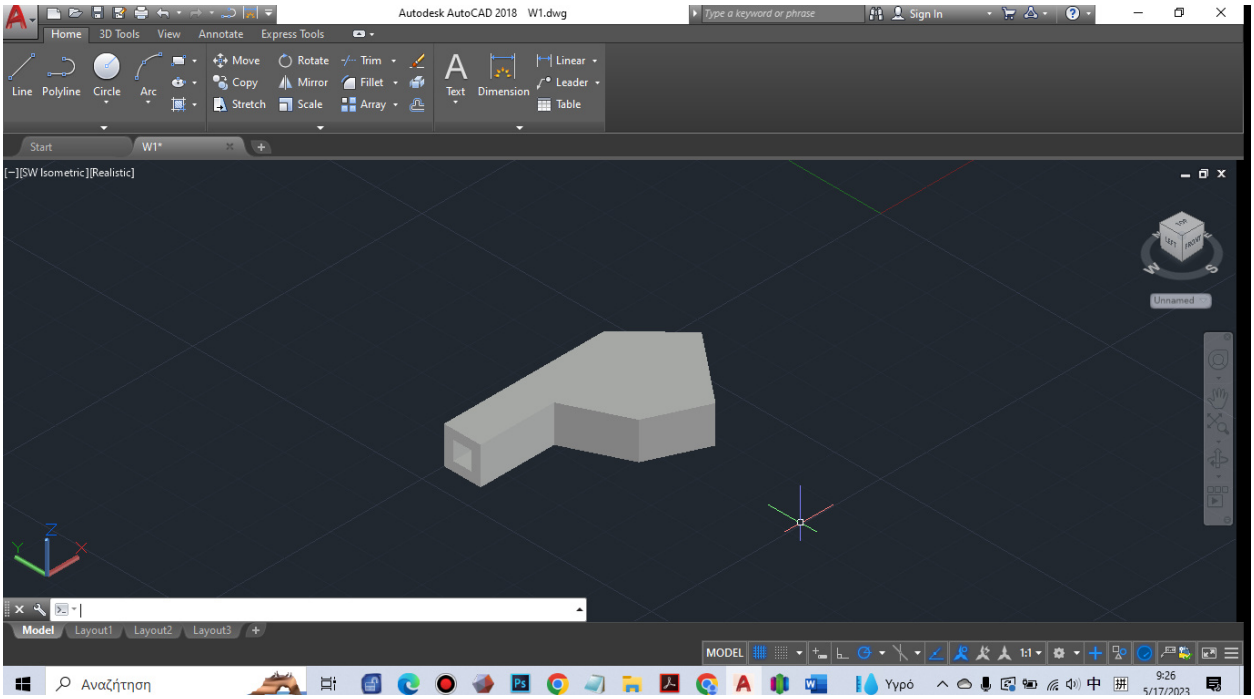




✓ That’s all !! So the design of the 3D object, the whistle, is completed and it is almost ready for 3D printing..

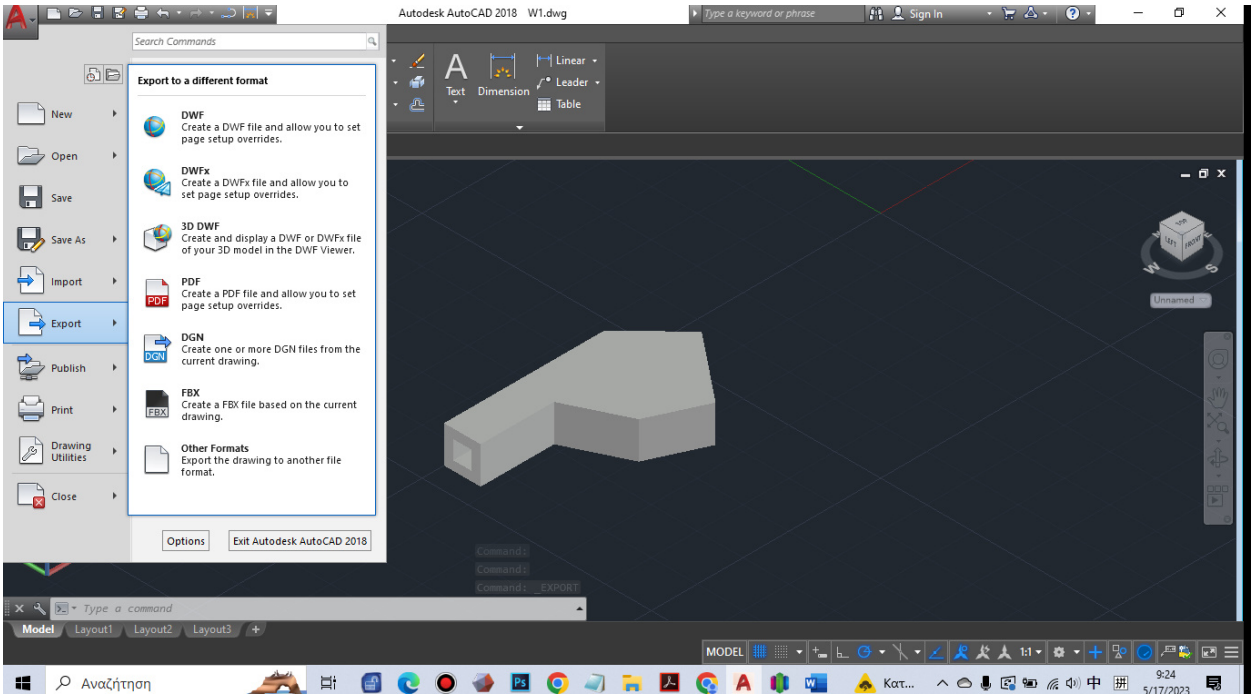


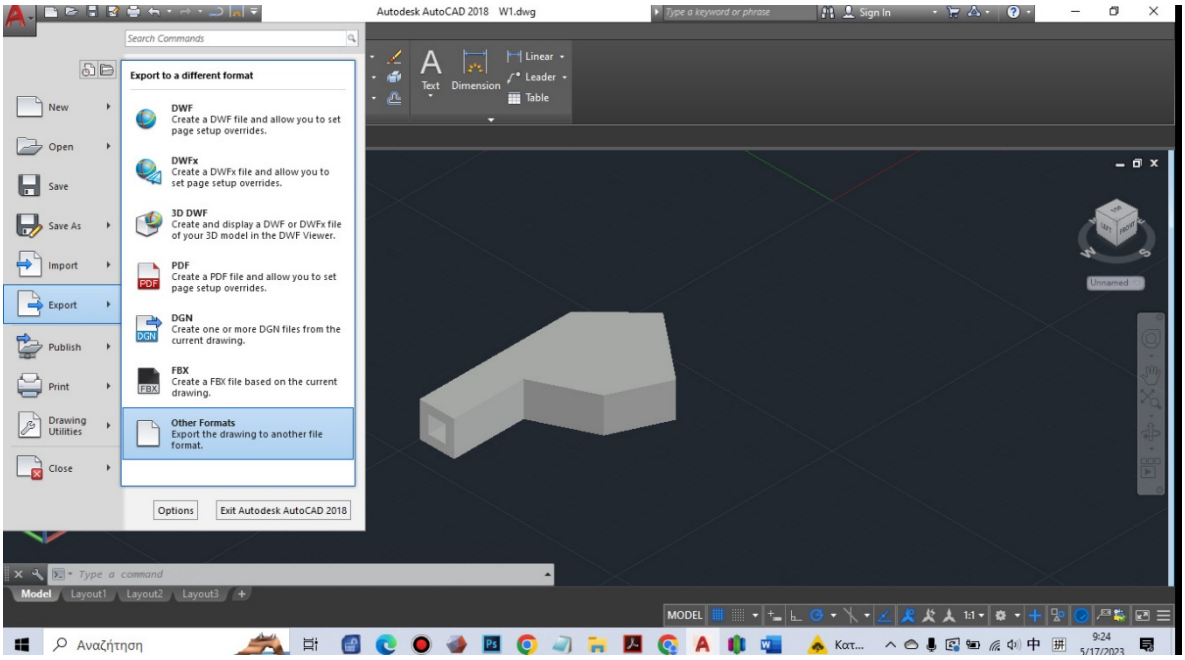
➢ 3D PRINTING OF THE WHISTLE



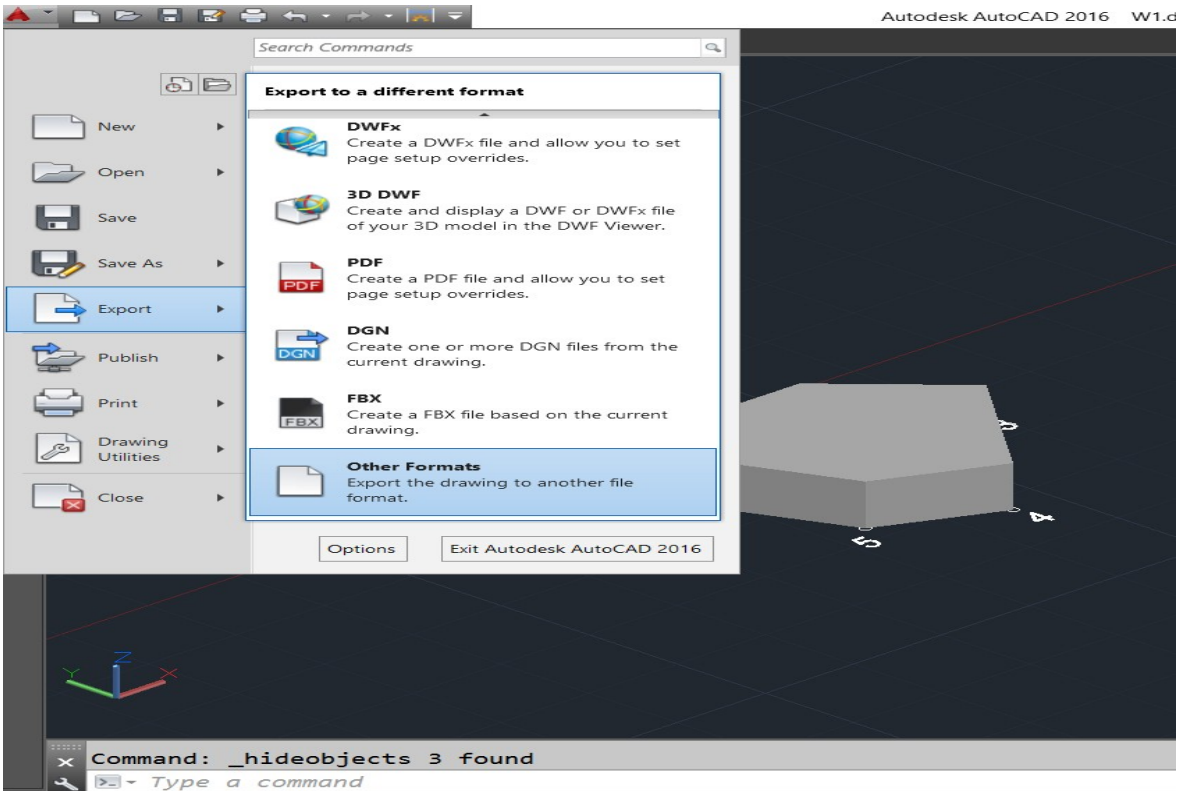
Having designed the 3D object, we export it and save it as an **stl file** format:

AutoCad icon "**A**" ⟶ "**EXPORT**" ⟶ "**OTHER FORMATS**", name and save the new stl file.

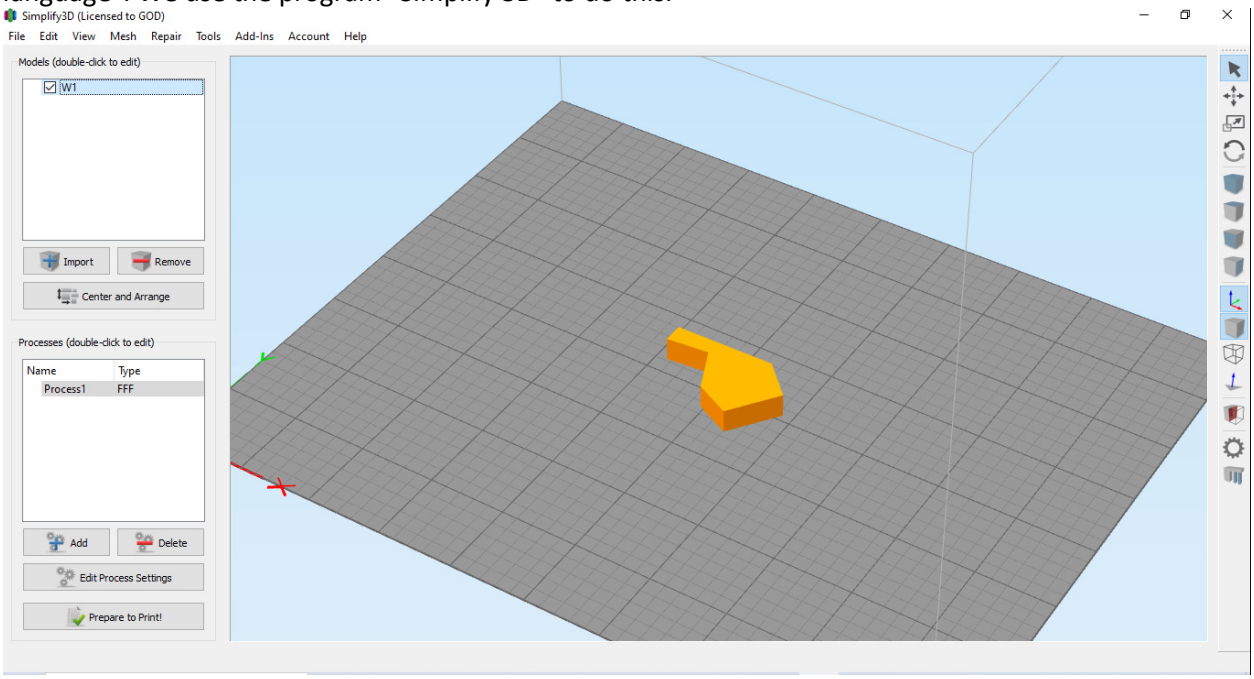




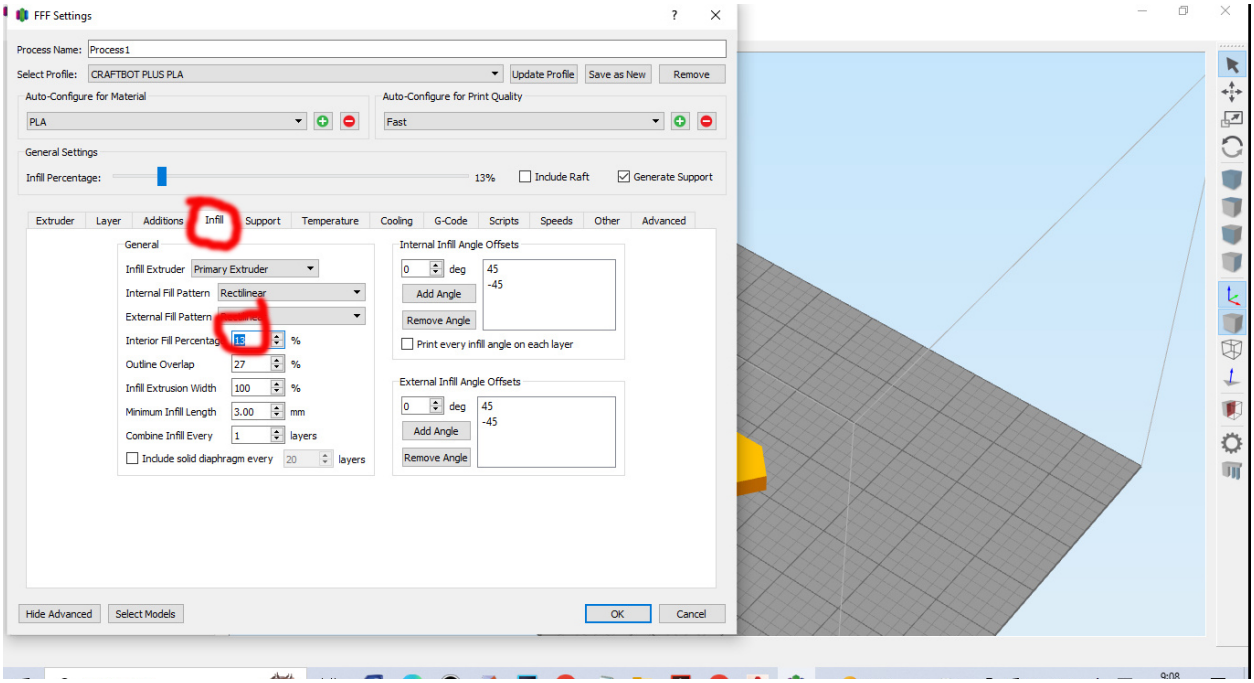
At the "**select objects**" prompt, we select the whistle and press "**ENTER**".



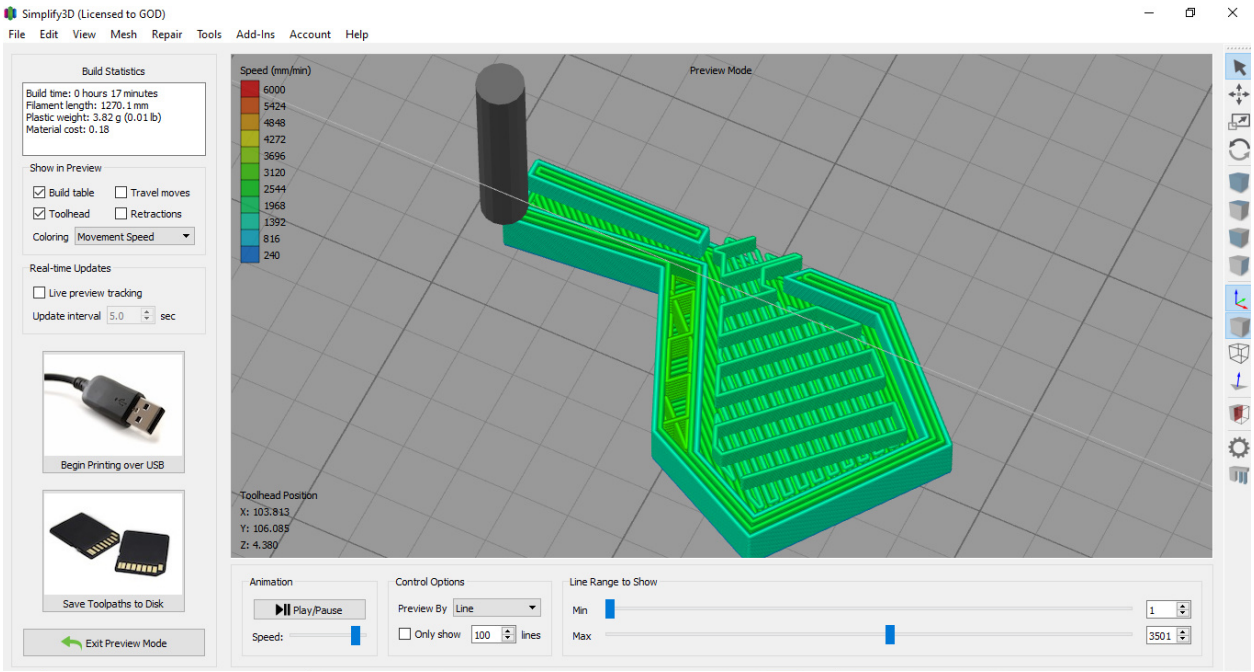
Then open the stl file in a "**slicer program**" to convert it into “**G-CODE** “ which is the “machine language”. We use the program "Simplify 3D" to do this.



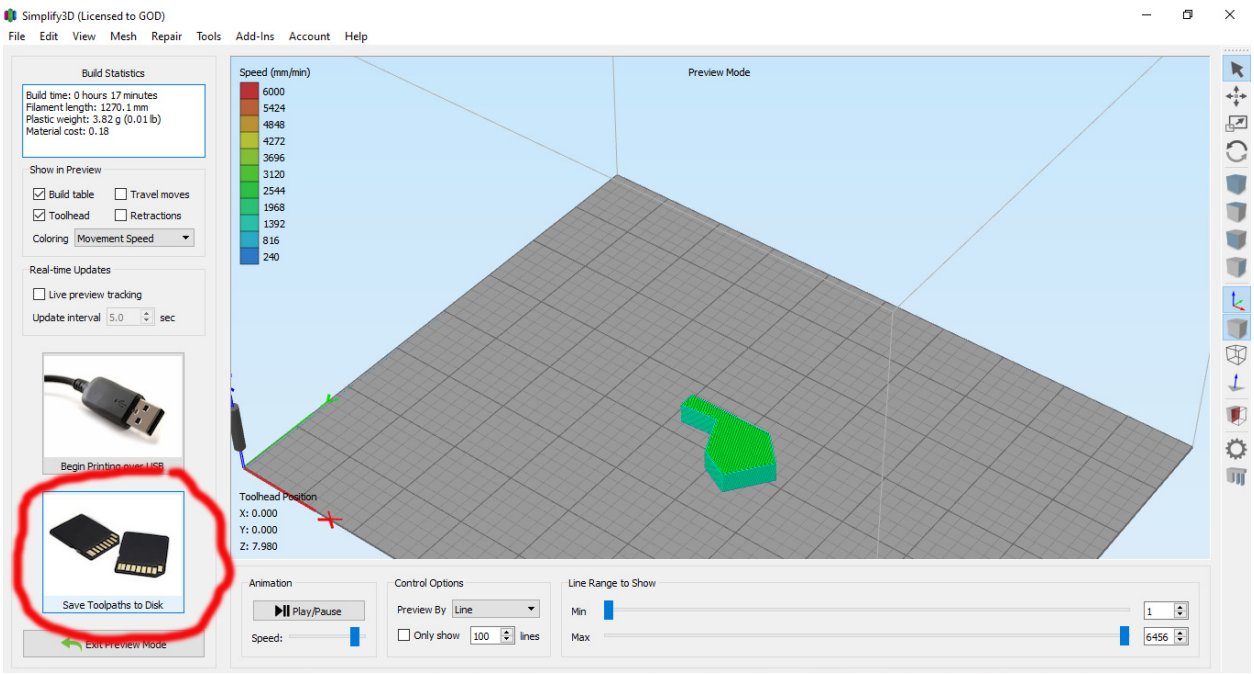
Once the stl file is imported into the slicer, we have already uploaded the profile of the printing. We can check some main printing parameters. For example, infill rate, we usually set the value to 13%.



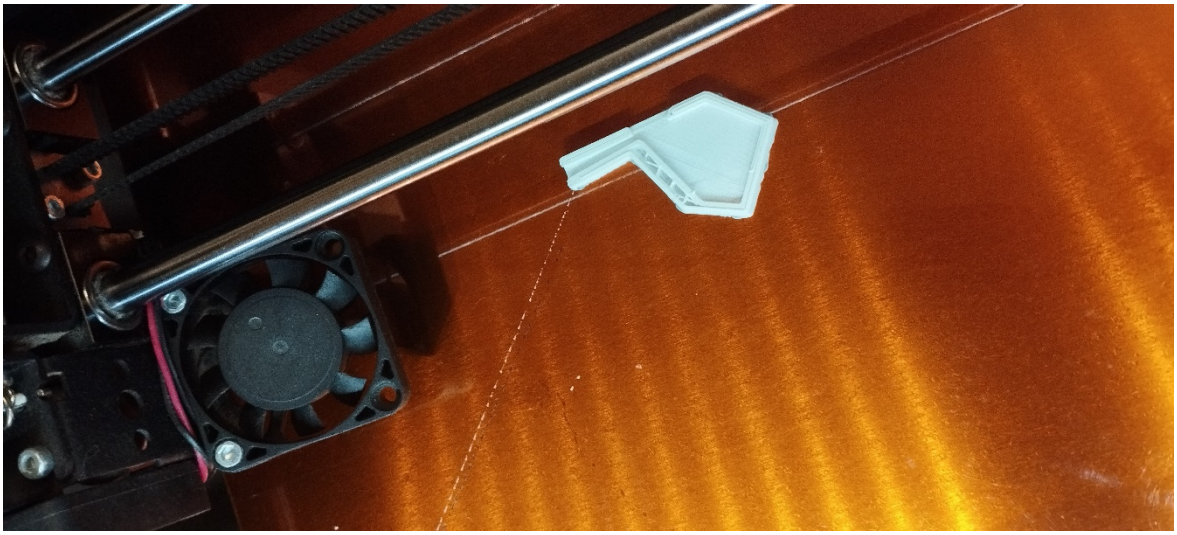
We press “**prepare to print**” button and the stl file is converted into a “**G-code**” file.

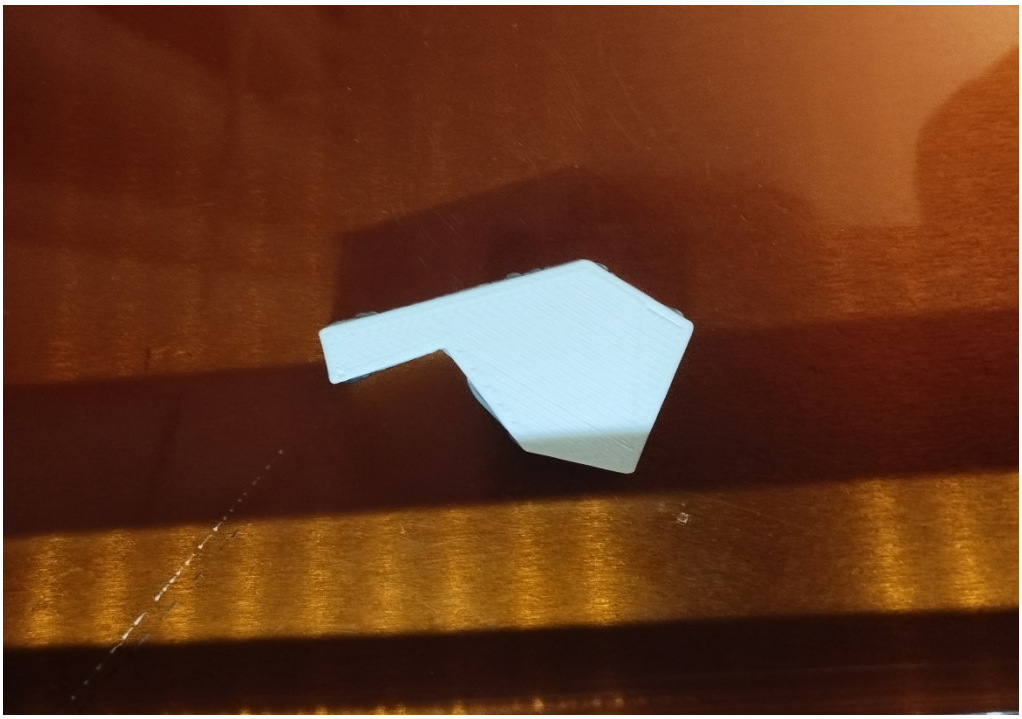


Then the “**Save toolpaths to disk**” and we save the G-code file in a USB flash disk.



Finally, we put the USB flash disk into the 3Dprinter USB slot and press “**print**”





- This is the final 3D object, the whistle which it can whistles!!!