Development of CNC Milling Machine

Guide By,
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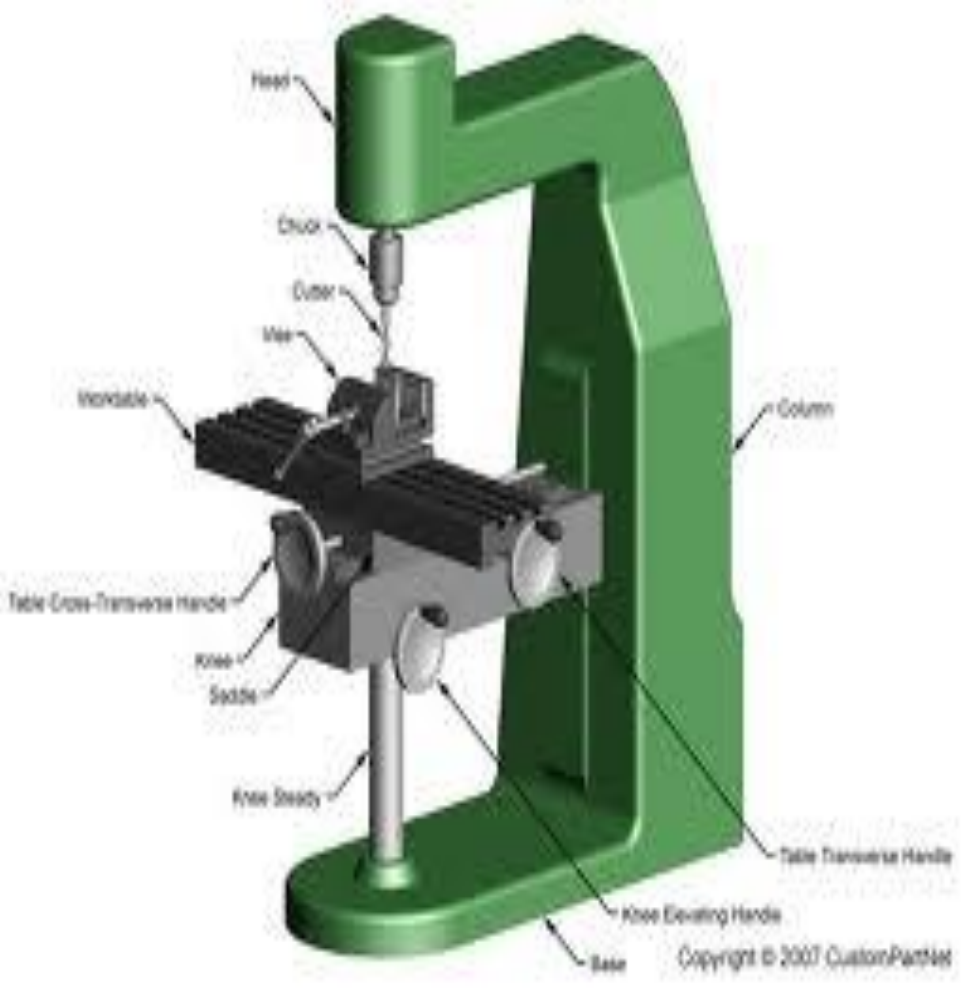
Introduction

A CNC machine is defined as a computer numerically controlled machine that is programmed and controlled through a computer that offers very short set up times and the flexibility to run.

- Today, they are widely used in manufacturing in combination with software programs to efficiently and consistently create different products for large companies or even single consumers.



Goal of Project

- The goal of this project is to design and build a high quality CNC which can perform multiple job functions by attaching different head styles. At the same time, the unit will have a minimum cost price point compared with other machines of similar functionality.

Objectives

- To develop more understanding about development and principle of CNC machine.
- To develop software that can generate machine command from G-code and draw drawing.
- To understand the fundamentals of part programming in terms of the various steps needed to be taken for completing a successful CNC program
- To develop a driver and an interfacing circuit between machine and PC.

CNC milling cost modeling

- A CNC machining job is subdivided into tool path generation, machining, tool replacement, and setup activities. Tool change and engagement activities are included in the machining activity. Correspondingly, the total CNC machining cost is the sum of tool path generation cost, machining cost, tool cost, material cost, setup cost, and overhead. The total cost of a CNC machining job will be

$$CNC\ Cost = C\ Tool\ path\ Generation + C\ Machining + C\ Tool + C\ Setup + C\ Material + C\ Overhead$$

C Tool path Generation is the cost of tool path generation. It can be calculated by the time used to design and generate the tool path multiplied by the programmer's salary rate

$$C\ Machining = Machining\ Time * (Machine\ Cost\ Per\ Hour + Labor\ Cost\ Per\ Hour)$$

To simplify the process and use existing CAD/CAM software, the machining time is directly read from CAM software after the user generates CNC tool path. Most CAM software can output all the operations in plain text format. This output includes tool cutting time, total machine time, and cutting operation parameters. The difference between the tool cutting time and total machine time is the tool change and engagement time. In this work the tool change and engagement cost is included in the total machining cost.

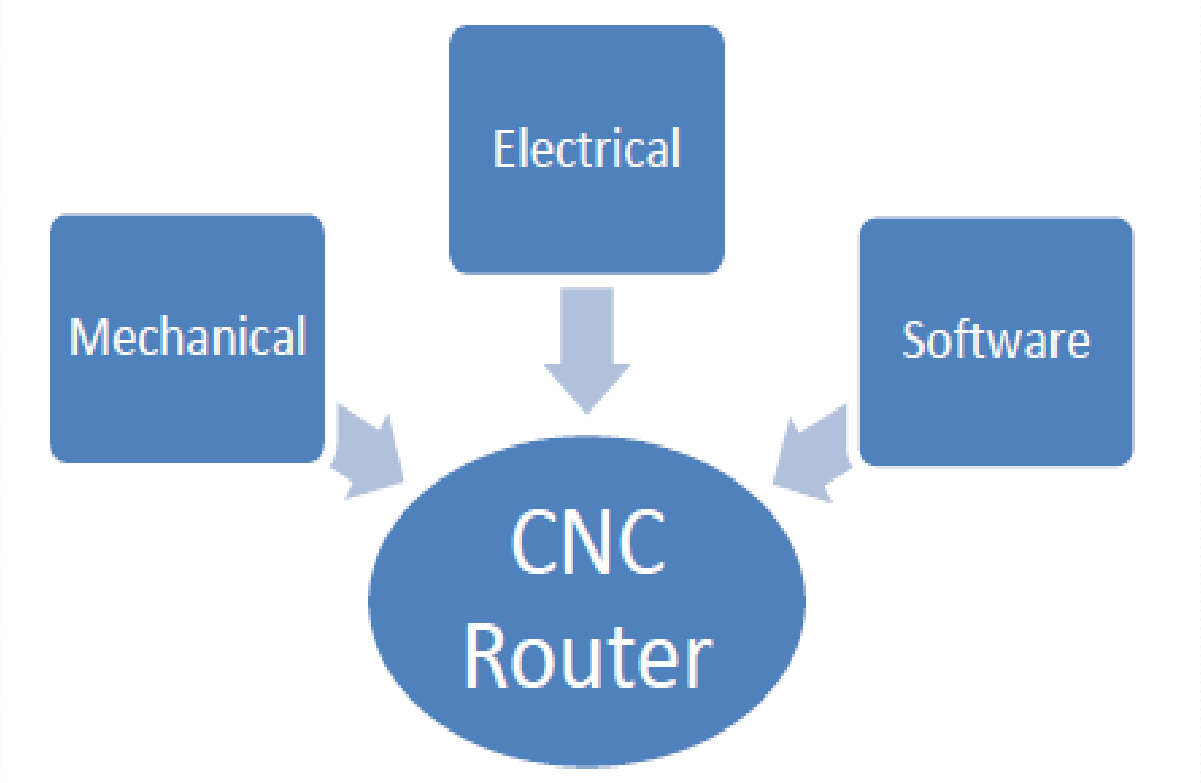
- Machine investment is converted to the machine cost per hour and is included in the cost to reflect the capital investment on the CNC machine.

$$Machine\ Cost\ Per\ Hour = \frac{Machine\ Purchase\ Cost}{Years\ of\ Return * Average\ Work\ Hours\ per\ Year}$$

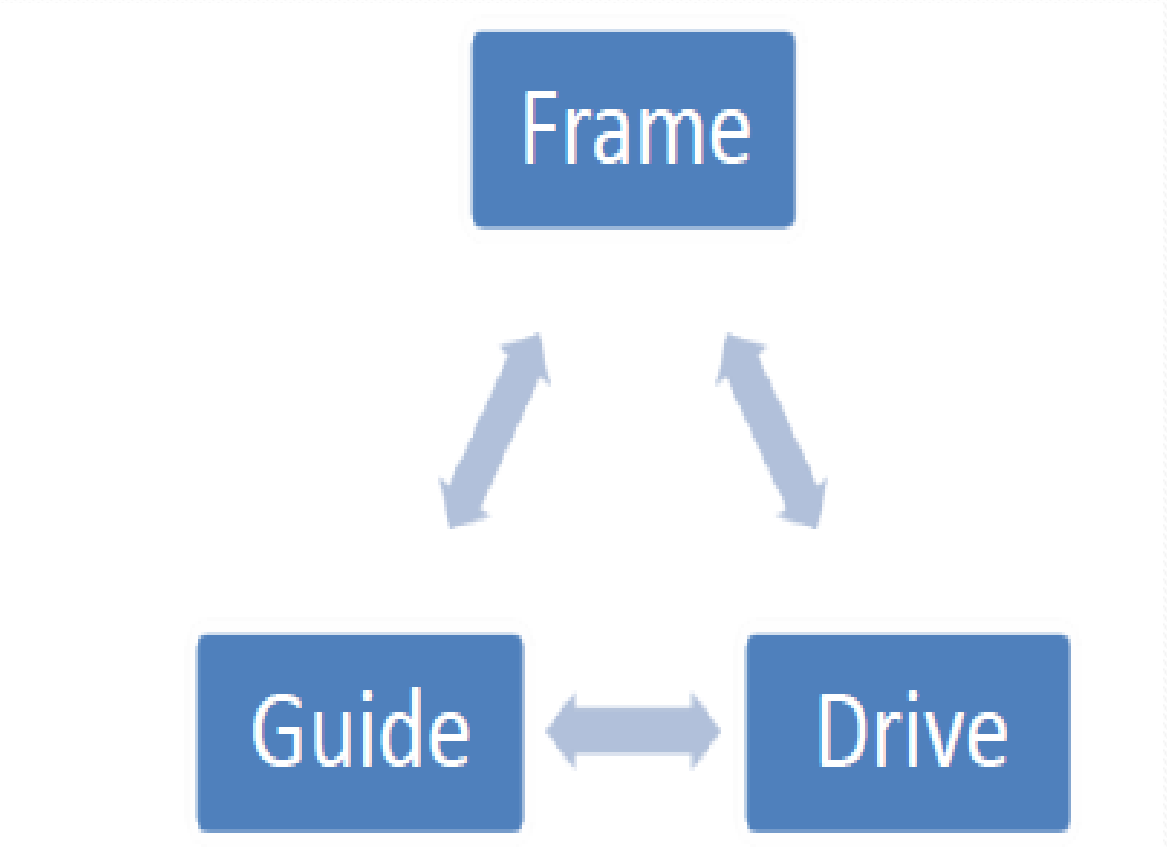
Project description

- The objective of this project is to design and build a CNC router which provides high quality features at a reduced cost compared with similar machines.
- It will further extend the traditional single task machines in such a way that multiple distinguishable tasks may be performed such as routing, PCB routing, solder paste dispensing, and airbrush operations.

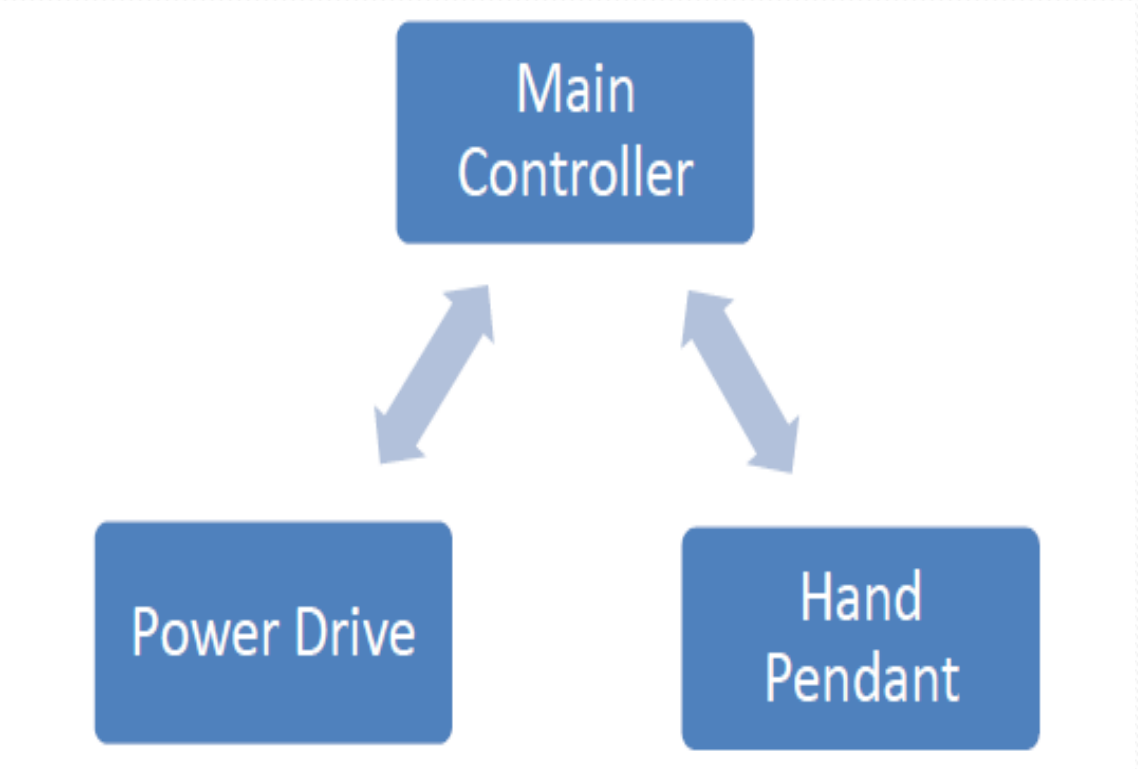
- There are three major subsystems to this CNC design as shown in Figure, they are:
  - Mechanical
  - Electrical
  - Software



- The mechanical subsystem, shown in Figure, is further broken down into the following subsections:
  - Frame
  - Drive
  - Guide



- The electrical subsystem, show in Figure 3-3, is further broken down into three primary electrical systems as follows:
  - Motion Controller
  - Power Drive
  - Hand Pendant



Frame

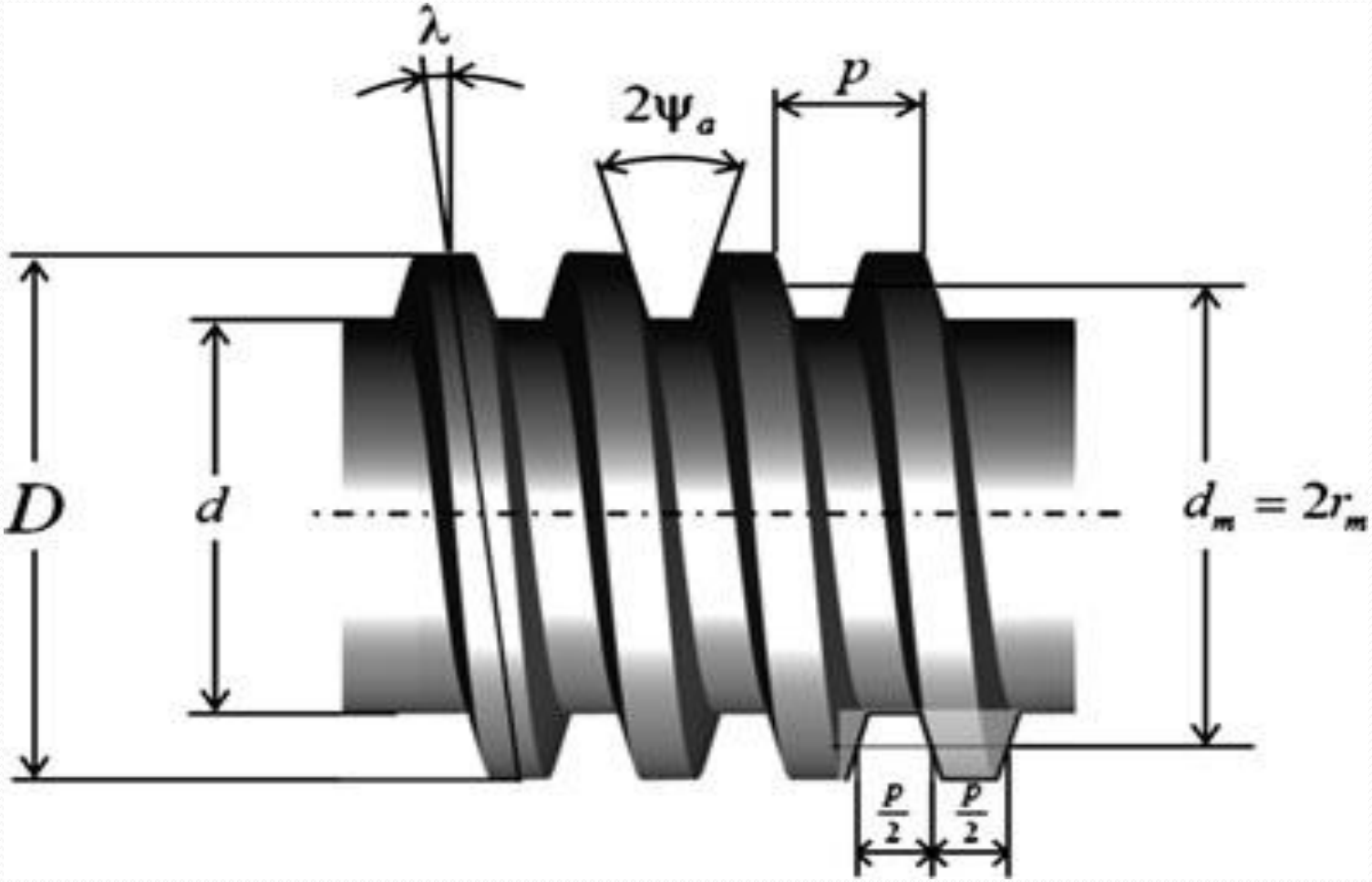
- A variety of materials have been used in the building of CNC machines. In comparing the materials there are five selection factors that need to be reviewed. CNC frame materials need to have some strength in order to support the weight of the gantry and the cutting head as well as withstand forces resulting from the milling process.
- Stiffness is also required to prevent any deflections due to both static forces and dynamic forces resulting from the acceleration of the tool head.

- Weight is also important because the mass of the frame contributes to both the static and acceleration forces. The best frame material would accomplish all three and offer excellent machine ability and be available at a low cost.
- Comparing metals and plastics is not easy as metals have a much higher strength and modulus of elasticity, but also have a greater weight and are more difficult to machine.
- It’s interesting to note that both steel and aluminum have similar stiffness to weight properties indicated by the ratio E/ρ, while the high grade aluminum has a significant advantage in strength to weight.

Drive

- Lead screws convert rotary motion to linear motion and come in a wide variety of configurations. Screws are available with different lengths, diameters, and thread pitches. Nuts range from the simple plastic variety to precision ground versions with re circulating ball bearings that can achieve very high accuracy.
- The combination of micro stepping and a quality leads crew provides exceptional positioning resolution for many applications. A typical 10-pitch (10 threads per inch) screw attached to a 200 step/rev. motor provides a linear resolution of 0.0125 per step.

- A flexible coupling should be used between the lead screw and the motor to provide some damping. The coupling will also prevent excessive motor bearing loading due to any misalignment
- Microscope Positioning
- Application Type: X/Y Point to Point
- Motion: Linear
- Description: A medical research lab needs to automate their visual inspection process. Each specimen has an origin imprinted on the slide with all other positions referenced from that point. The system uses a PC-AT Bus computer to reduce data input from the operator, and determines the next data point based on previous readings. Each data point must be accurate to within 0.1 microns.
- Machine Objectives
- • Sub-micron positioning
- • Specimen to remain still during inspection
- • Low-speed smoothness (delicate equipment)
- • Use parallel port computer circuit


λ
2ψ₀
p
D
d
$d_m = 2r_m$
p/2
p/2

Guide

- The first frame subsystem design to consider would be a conventional railing system, which consists of a linear motion bearing and shaft assembly which would simply allow unrestricted movement along their lengths. The most logical rail design to consider, given the design specifications and size requirements, would be the sort of railing that could be supported in some way to handle the loads applied to it without much deflection.

- In this railing systems such as these, information was found which could give some insight into the reasonable values of a system such as this. For instance, the railing system shown here has a simple steel shaft railing system and is light weight. For many years there have been vast improvements made in rail design to help increase the performances of the rail system.

- Steel shaft railing, as seen in Figure is both a simple and efficient design for linear motion applications. The shaft provides support to loading applications along the shaft, along with forces generated from linear motion, which makes this a perfect concept for this particular system.

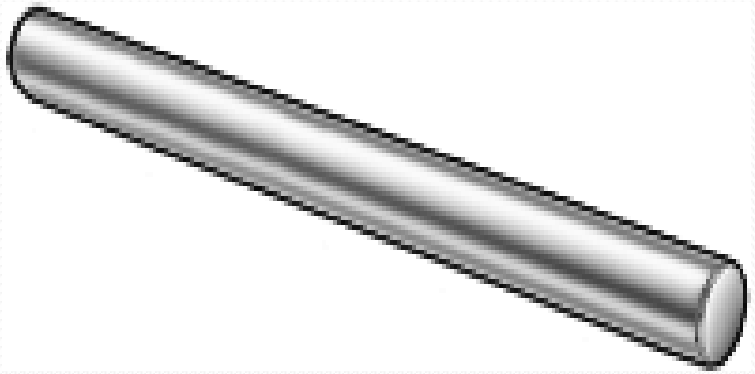
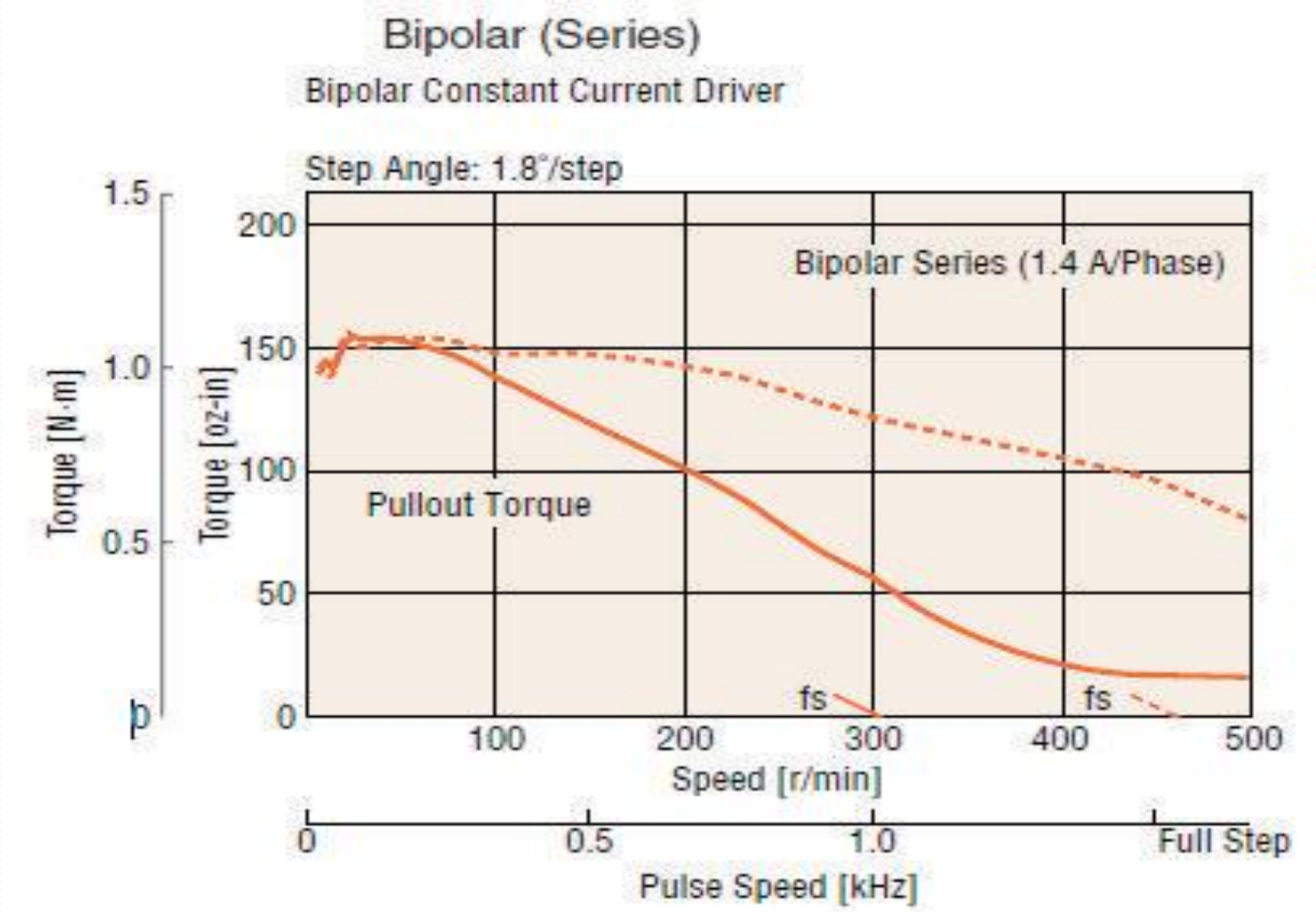


Figure: Shaft

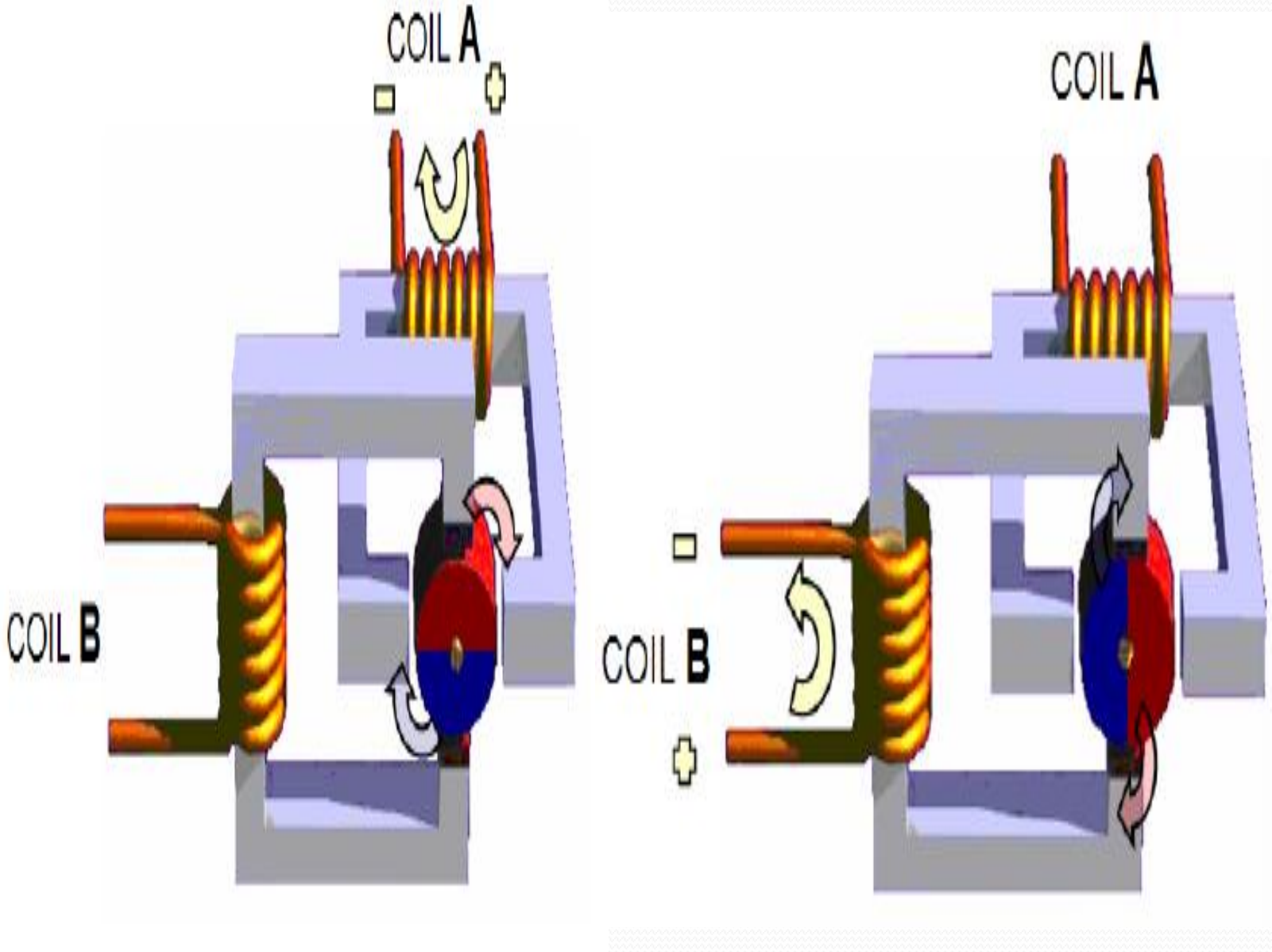
Stepper motor

- A stepper motor is a small brushless synchronous electric motor that can divide a full rotation into a large number of steps. If it is electronically connected to the MCU, the motor's position can be controlled with precision without any feedback mechanism.
- Steppers exhibit more vibration than other motor types. The discrete step tends to snap the rotor from one position to another. This vibration can cause the motor to lose torque at some speeds.

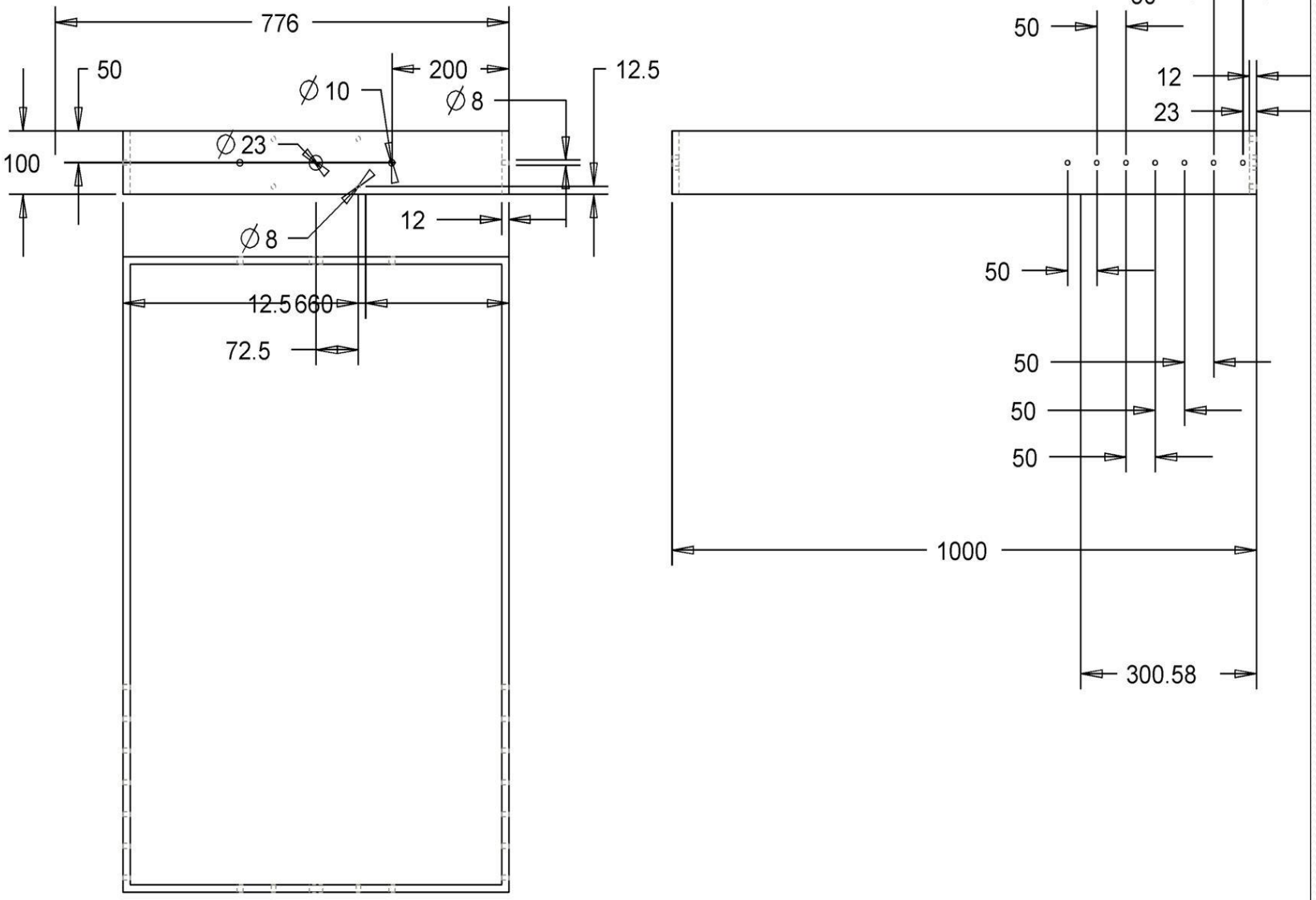
- The effect can be mitigated by accelerating quickly through the problem speed range, physically dampening the system, or using a micro-stepping driver. Motors with a greater number of phases have a smoother operation than those with fewer phases.
- There are two basic arrangements for the electromagnetic coils: unipolar and bipolar. This application note focuses on a bipolar motor.
- A bipolar motor is built with two different coils, which in this document are named coil A and coil B. Since each coil has two wires, a bipolar stepper motor has four different wires.

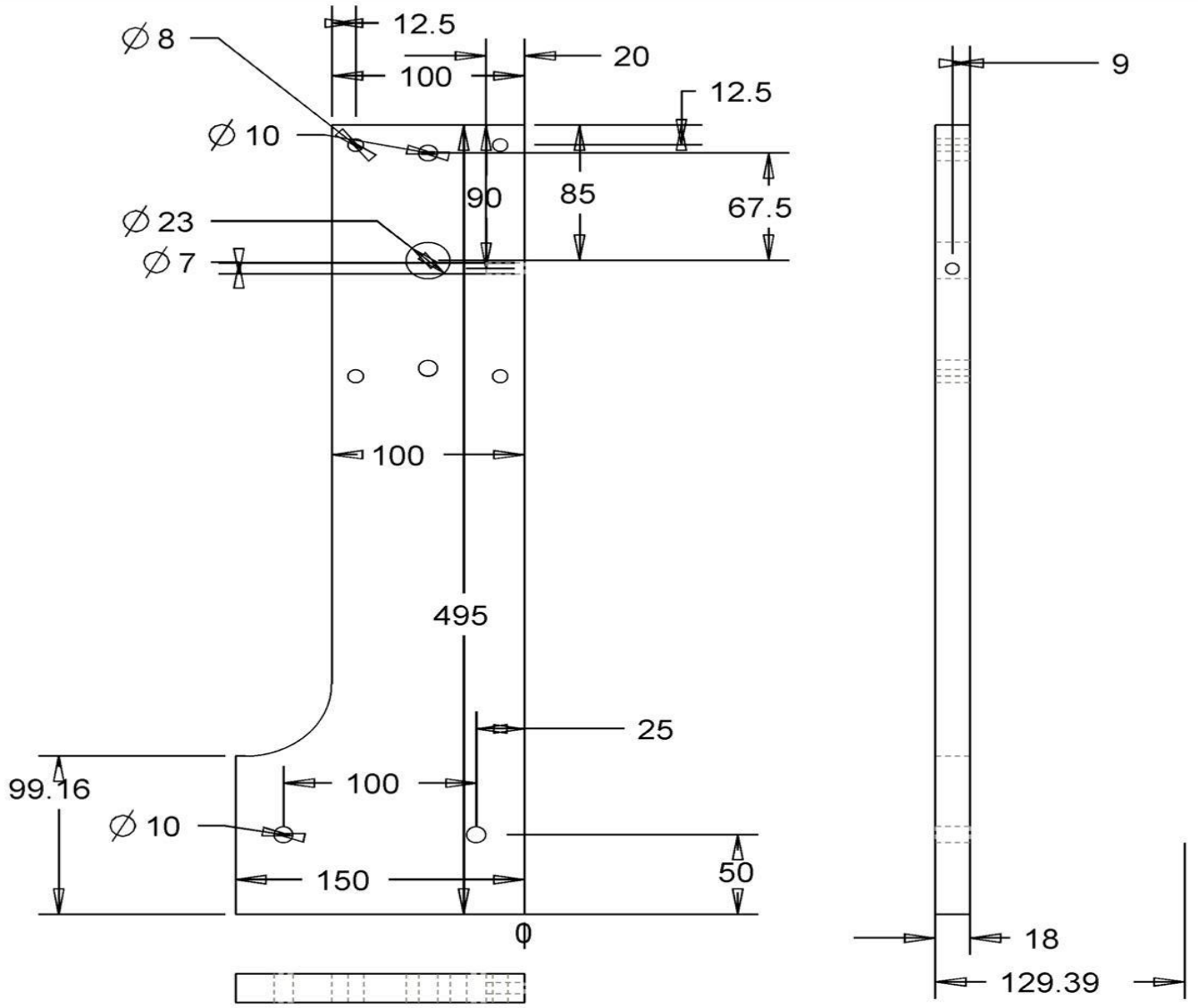

Bipolar (Series)
Bipolar Constant Current Driver
Step Angle: 1.8°/step
Bipolar Series (1.4 A/Phase)
Pullout Torque
fs
fs
Torque [N·m]
Torque [oz-in]
1.5
1.0
0.5
0
200
150
100
50
0
100
200
300
400
500
Speed [r/min]
0
0.5
1.0
Full Step
Pulse Speed [kHz]

- Bipolar stepper motors operate differently from traditional DC motors. Stepper motors have multiple toothed electromagnets arranged around a central metal gear. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor turn, the following steps are required:
- 1. Coil A is connected to the power that causes the gear's teeth to be magnetically attracted to the electromagnet's teeth.
- 2. The gear's teeth are aligned to the first electromagnet. Next, they are aligned to the second electromagnet.
- 3. Coil B is then turned on and coil A is turned off.
- 4. The gear then rotates to be aligned with the next gear.
- 5. Repeat the process described in steps 1 to 4.


COIL A
COIL B
COIL A
COIL B

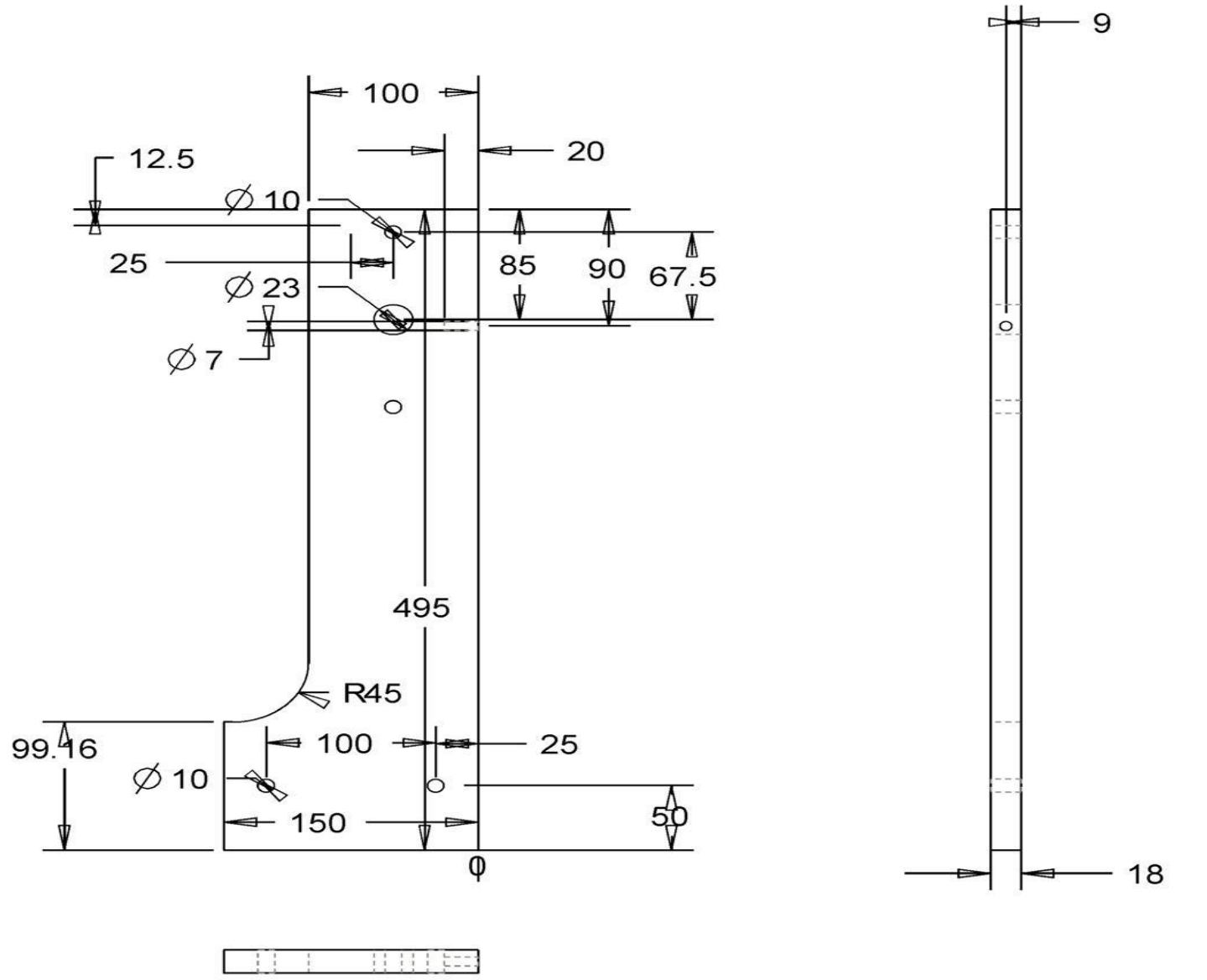
Design of part


776
50
200
12.5
∅10
∅8
∅23
100
12
∅8
12.5
660
72.5
50
50
12
23
50
50
50
50
1000
300.58
SCALE 0.130
BASE



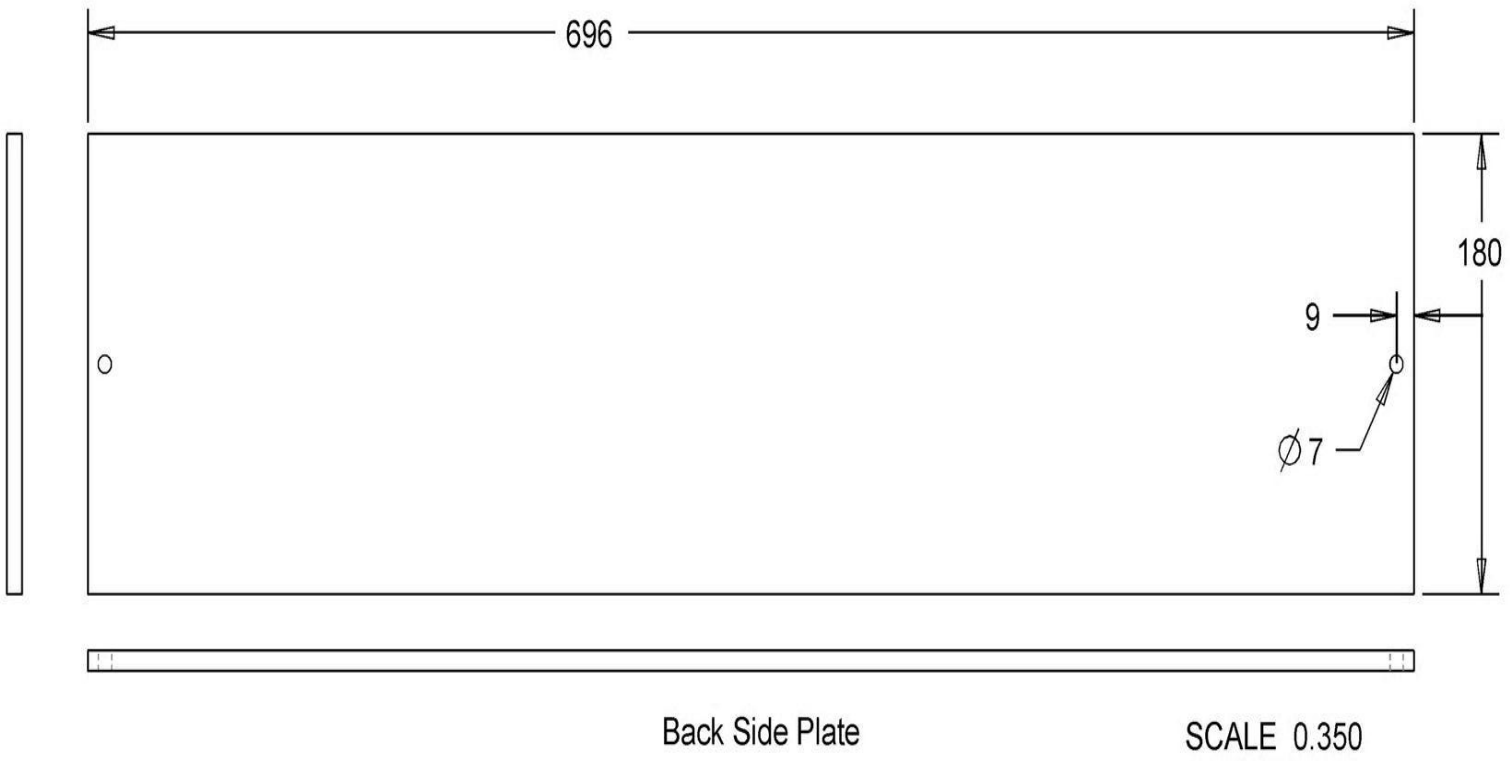
SCALE 0.300

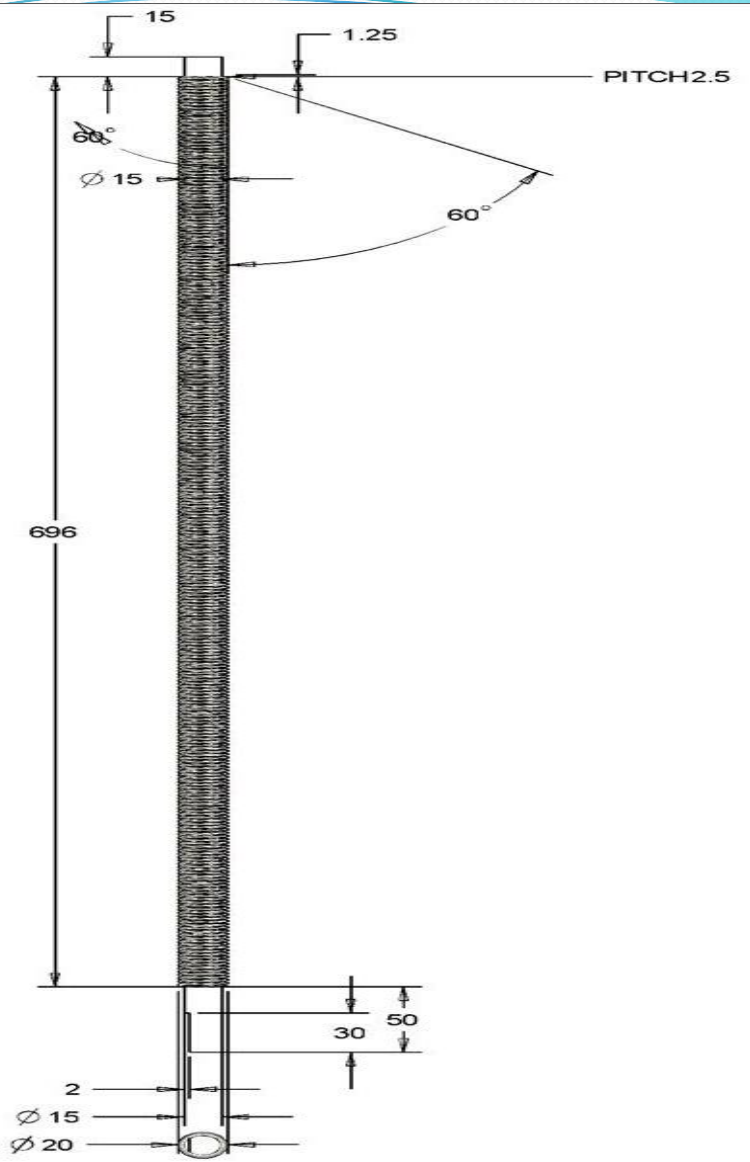
RIGHT SIDE SUPPORT PLATE



SCALE 0.250

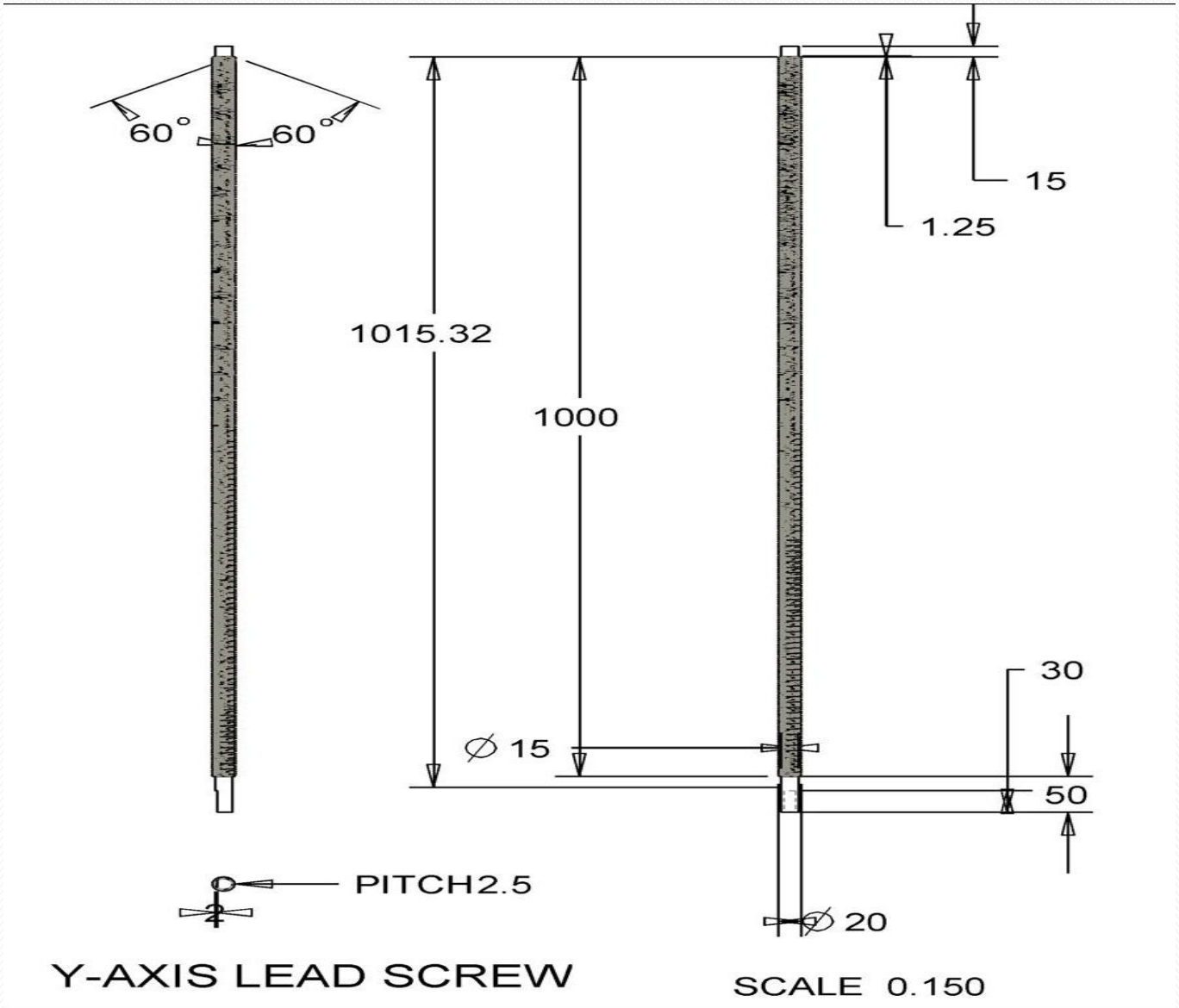
LEFT SIDE SUPPORT PLATE

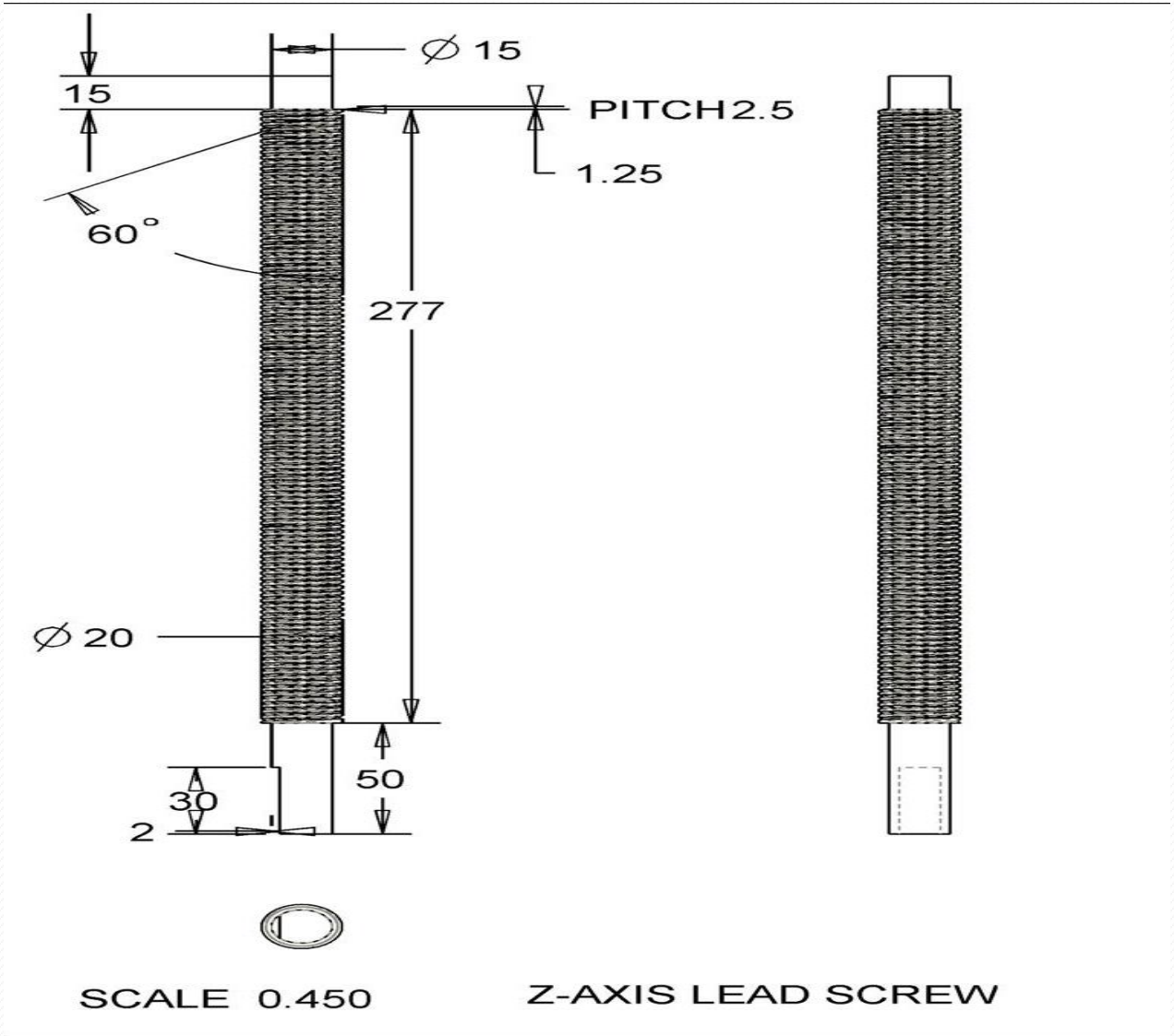

696
180
9
Ø7
Back Side Plate
SCALE 0.350

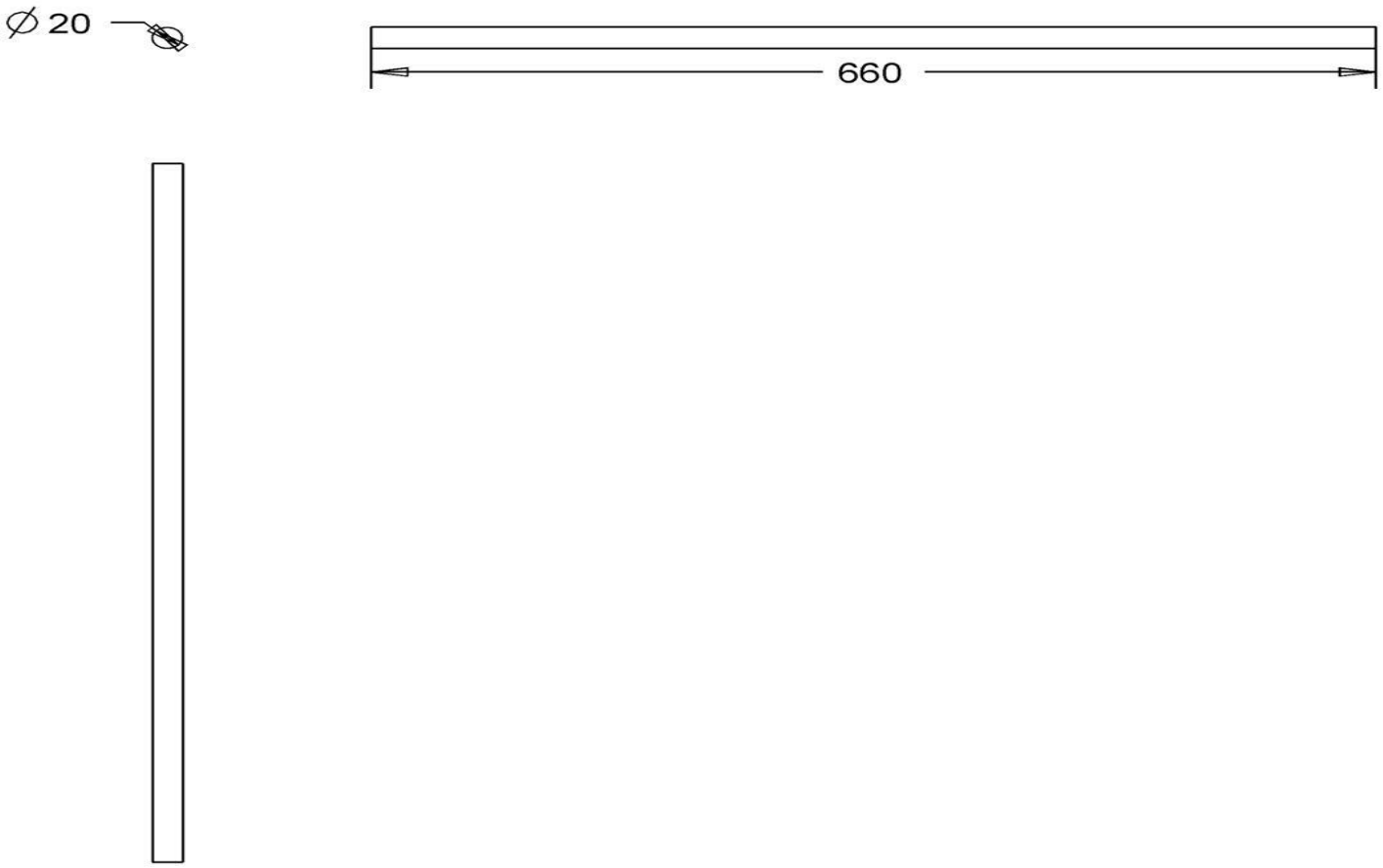


SCALE 0.450

X-AXIS LEAD SCREW

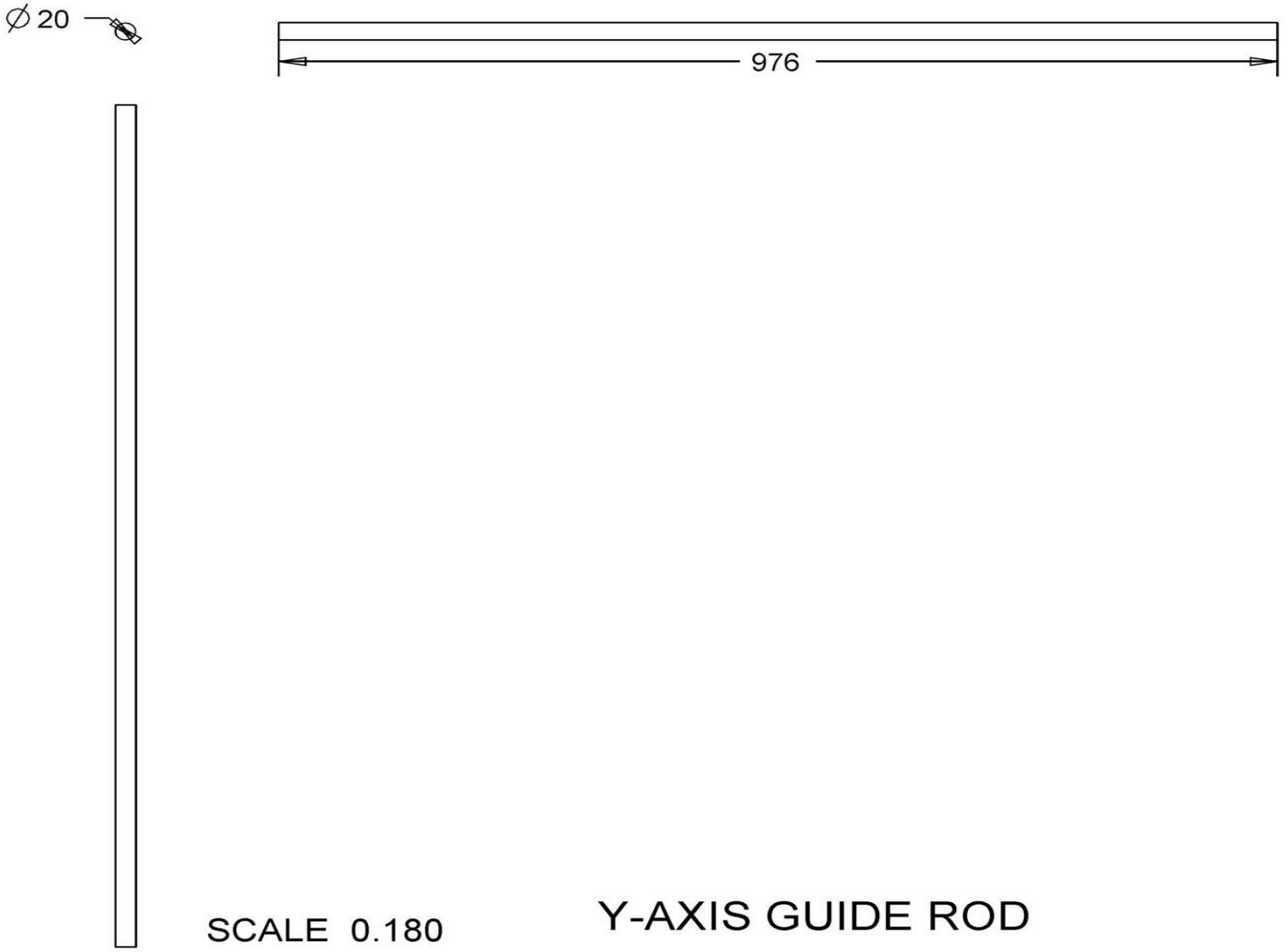

60°
60°
15
1.25
1015.32
1000
30
∅ 15
50
PITCH2.5
∅ 20
Y-AXIS LEAD SCREW
SCALE 0.150

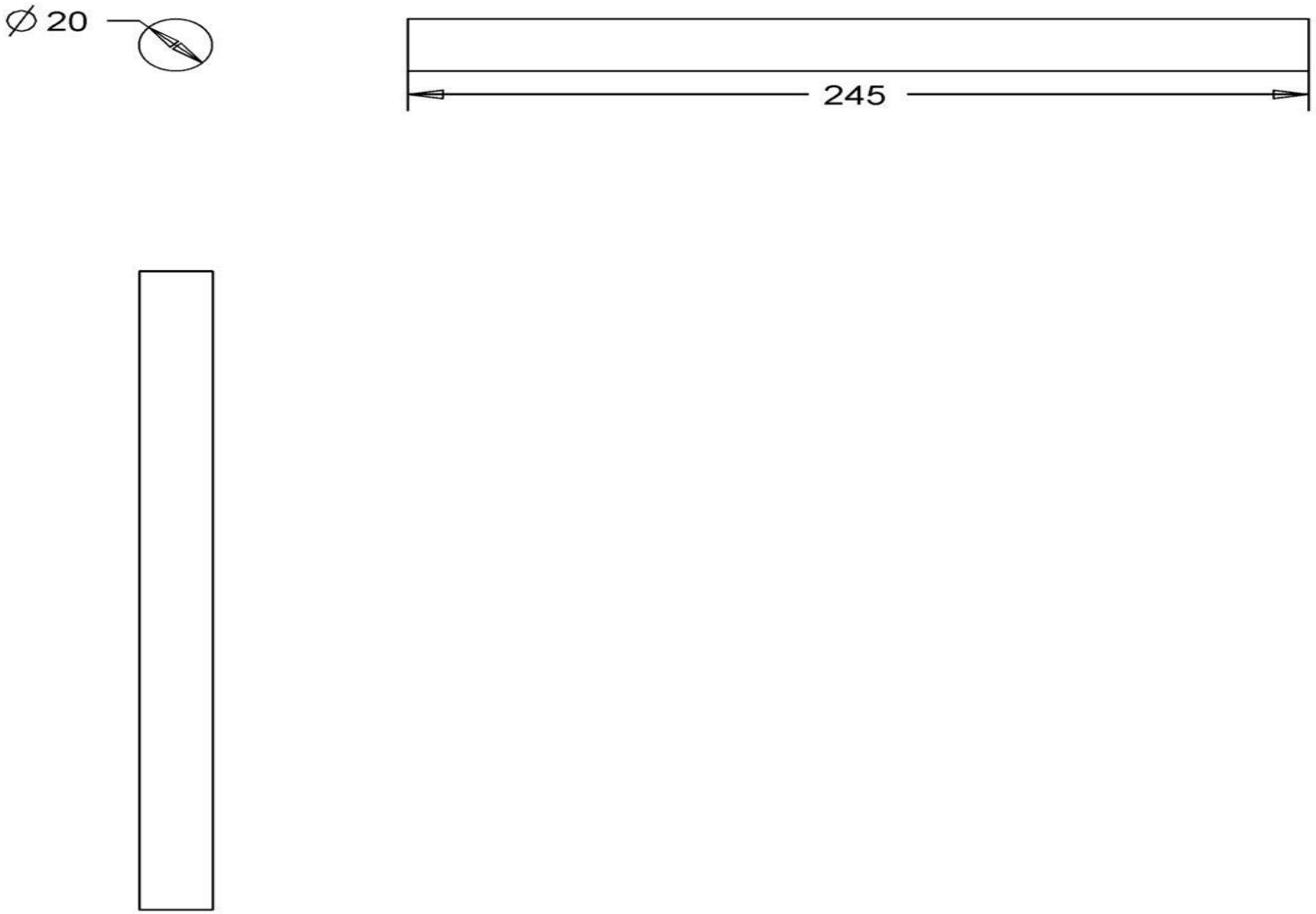

∅ 15
15
PITCH2.5
1.25
60°
277
∅ 20
50
30
2
SCALE 0.450
Z-AXIS LEAD SCREW

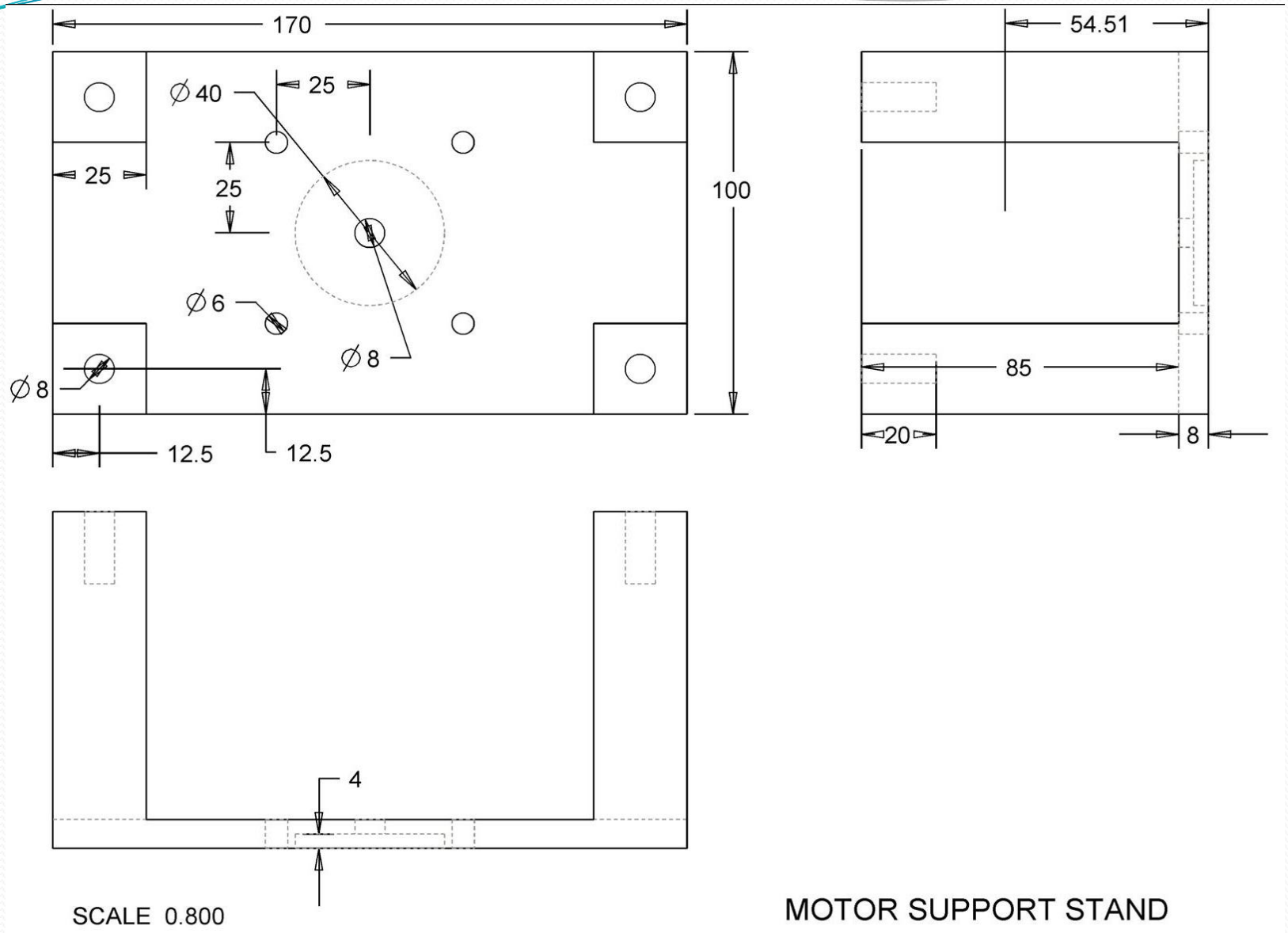


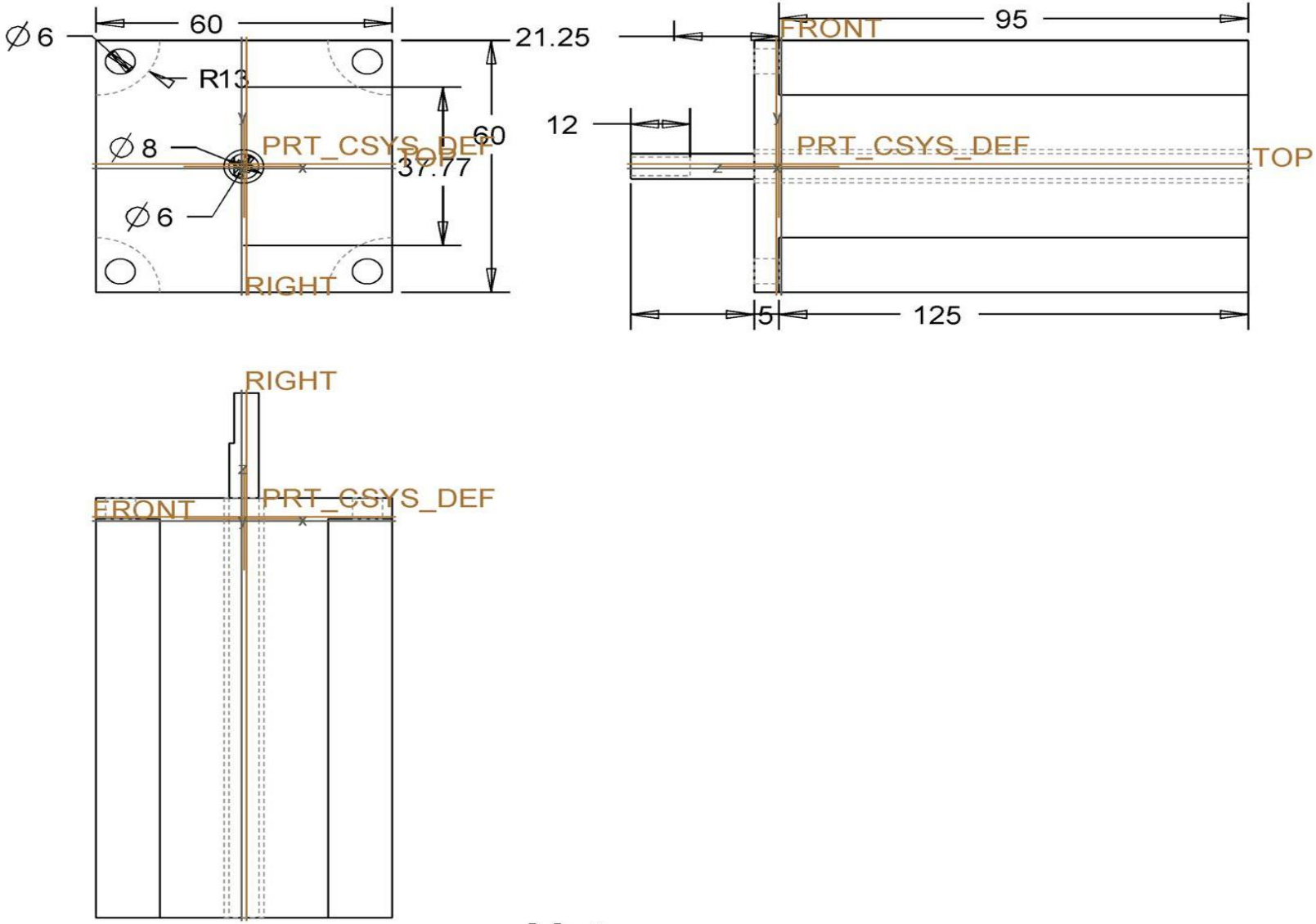
SCALE 0.200

X-AXIS GUIDE ROD

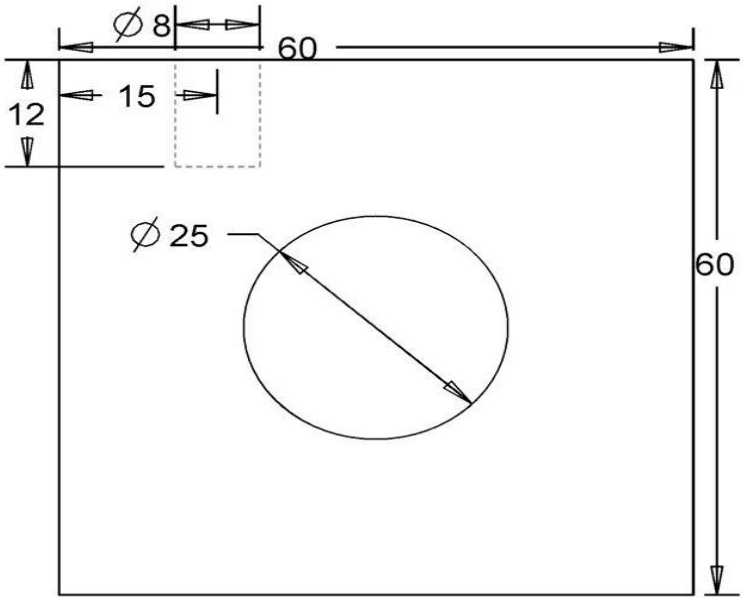

∅20
976
SCALE 0.180
Y-AXIS GUIDE ROD

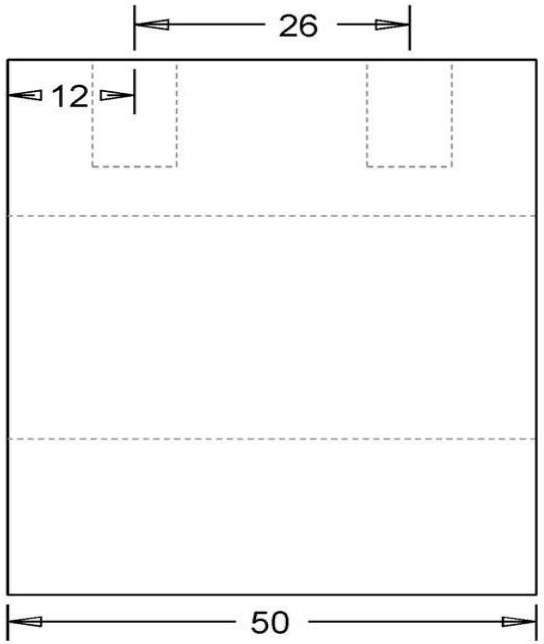

∅ 20
245
SCALE 0.500
Z-AXIS GUIDE ROD

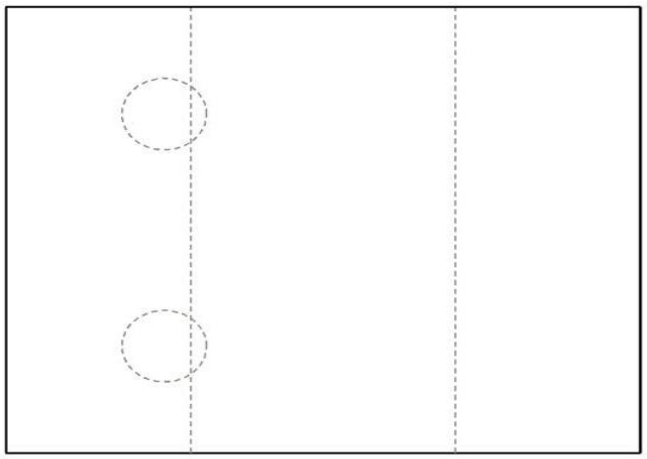

170
54.51
∅40
25
25
25
100
∅6
∅8
∅8
85
20
8
12.5
12.5
4
SCALE 0.800
MOTOR SUPPORT STAND


∅6
60
21.25
R13
∅8
PRT_CSYS_DEF
TOP
37.77
60
∅6
RIGHT
FRONT
95
12
PRT_CSYS_DEF
TOP
5
125
RIGHT
FRONT
PRT_CSYS_DEF
SCALE 0.850

Motor

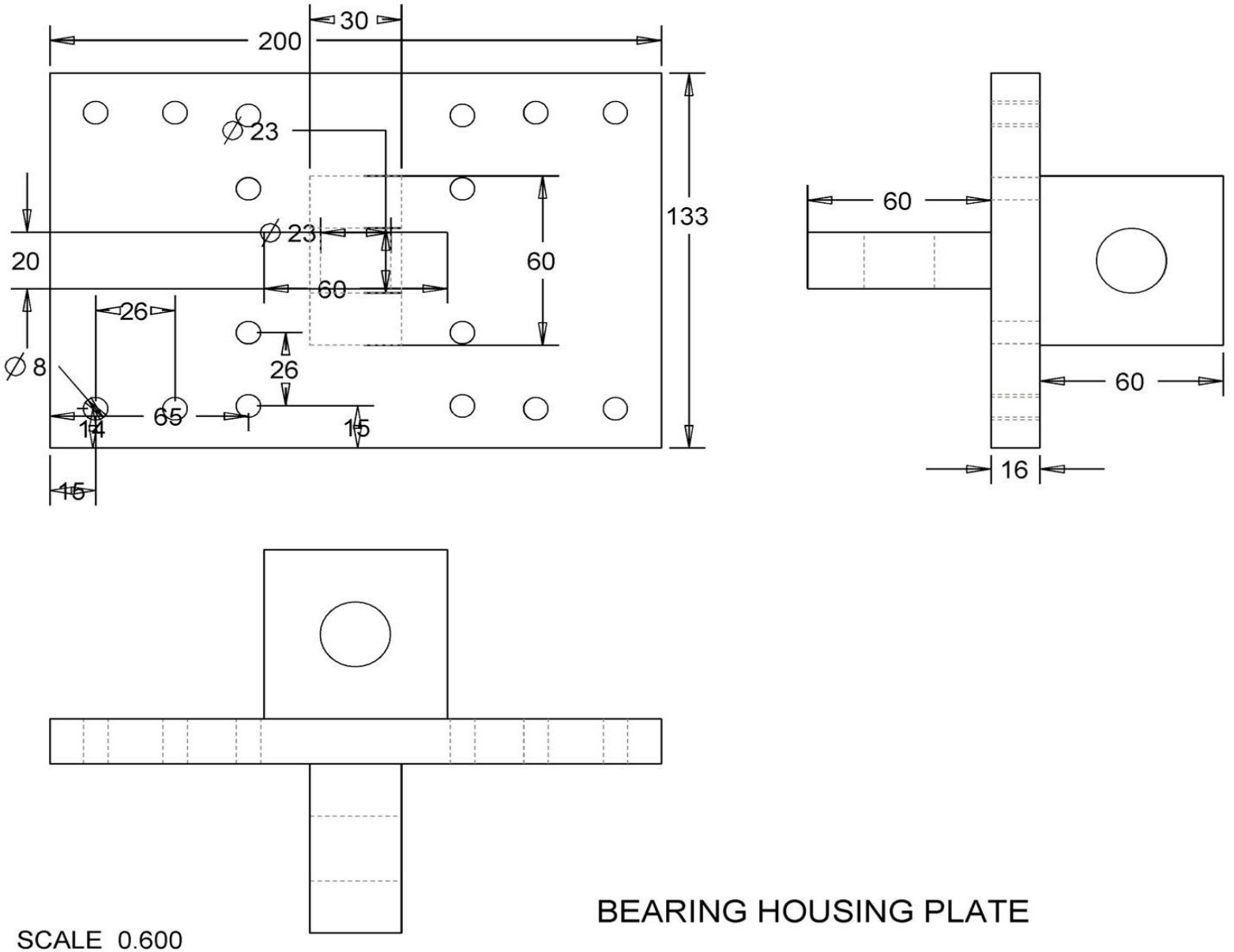


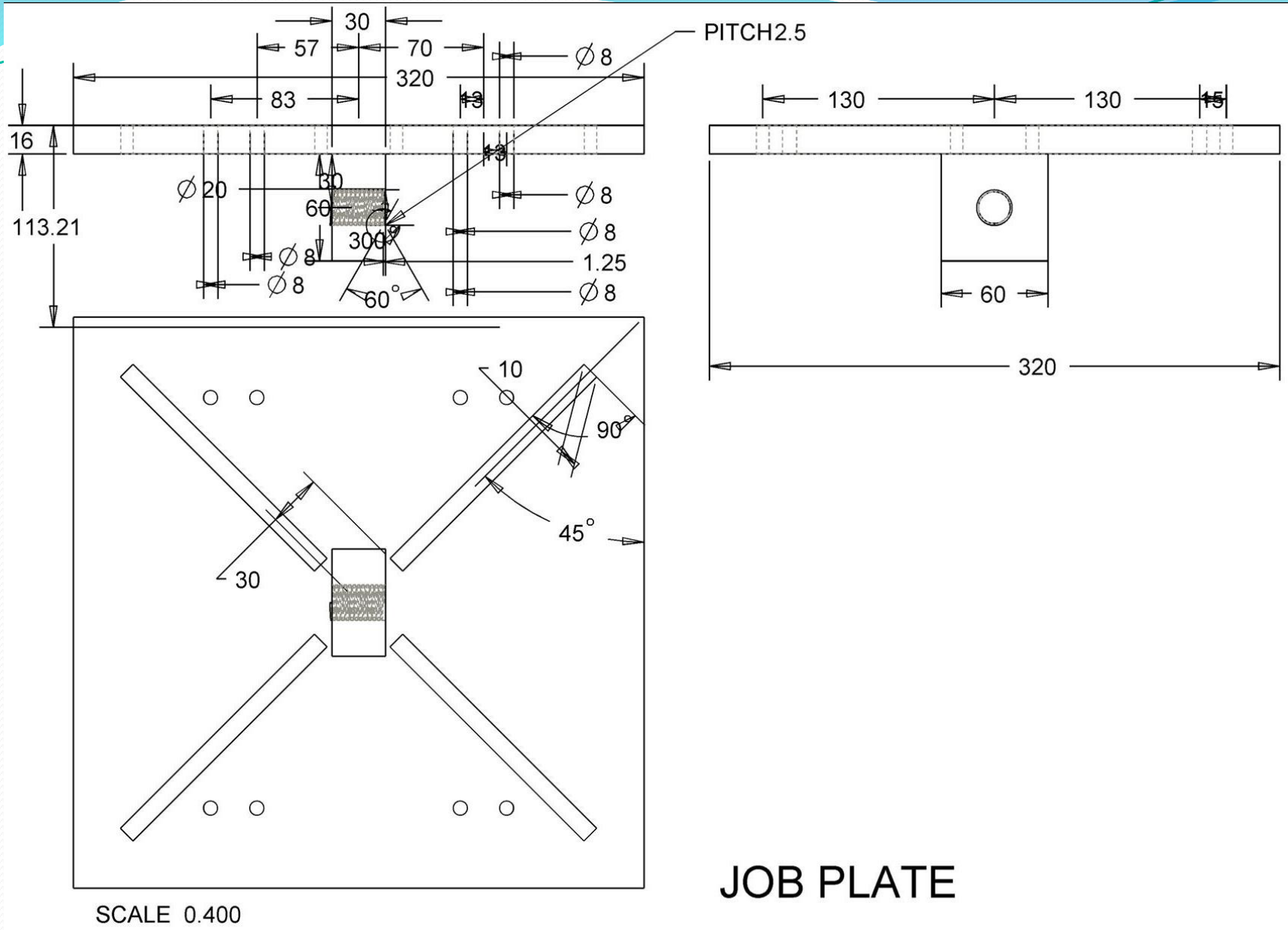




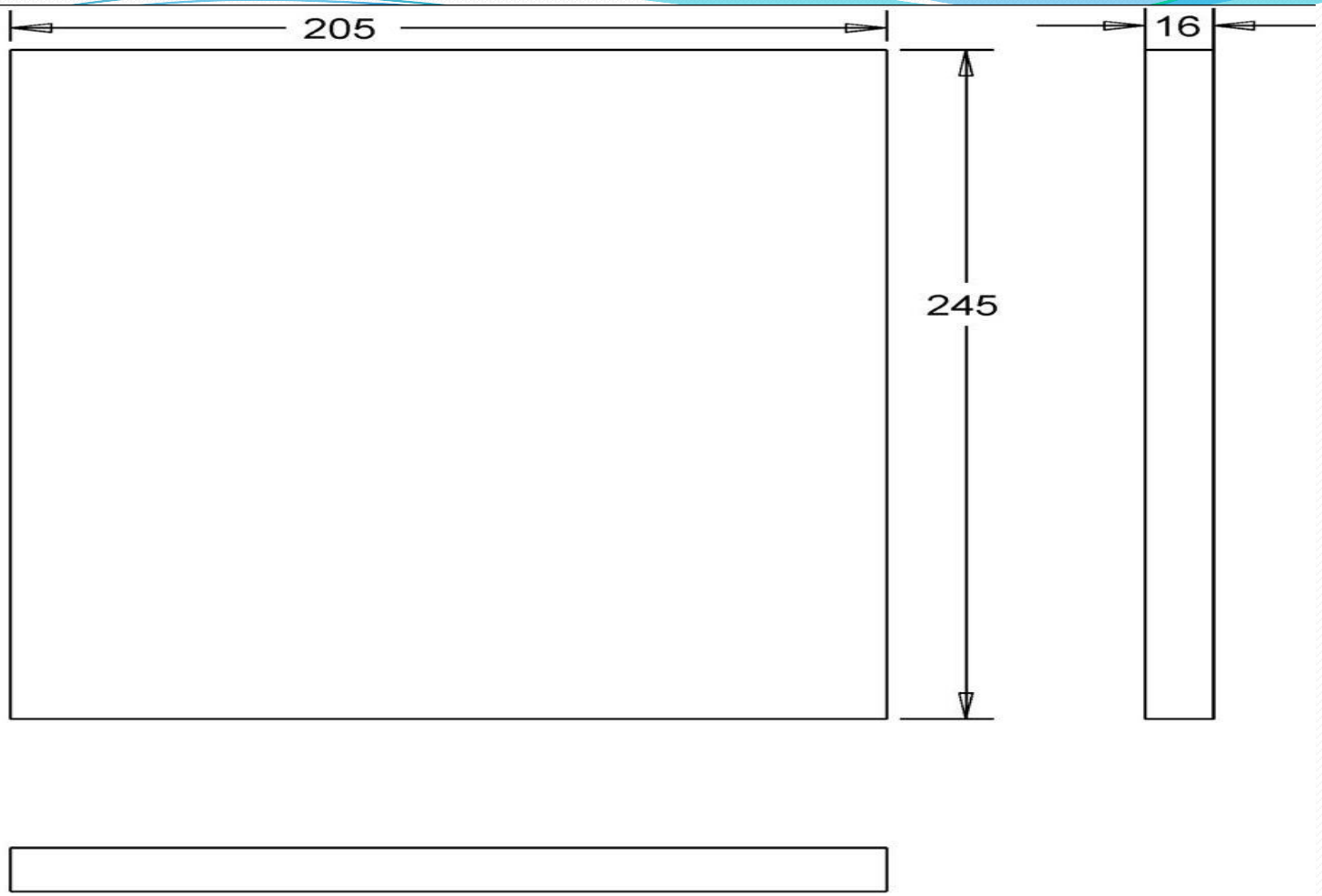
SCALE 1.500

BEARING HOUSING


200
30
∅23
133
20
∅23
60
60
26
∅8
26
65
15
15
60
60
16
SCALE 0.600
BEARING HOUSING PLATE

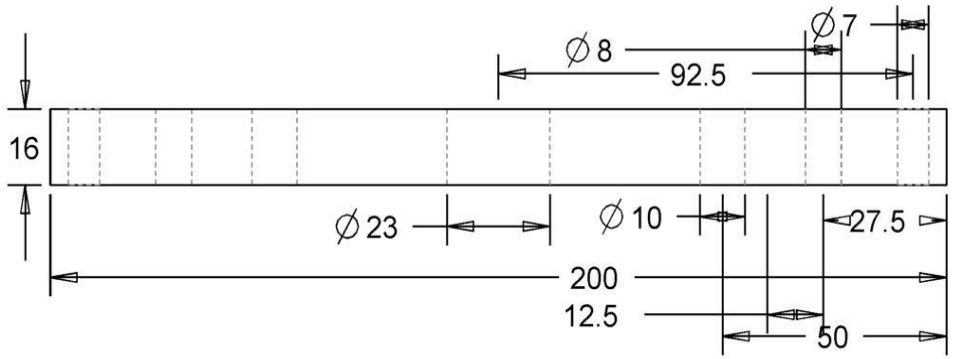

30
57
70
320
83
16
113.21
Ø20
Ø8
60
300
1.25
60°
PITCH2.5
130
130
60
320
10
90°
45°
30
SCALE 0.400

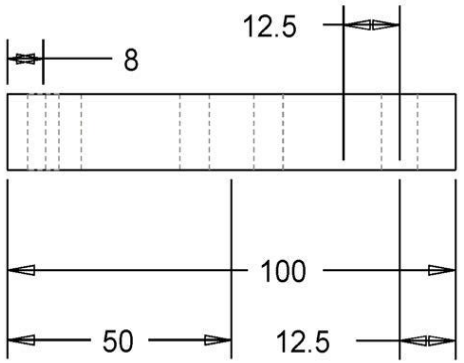
JOB PLATE

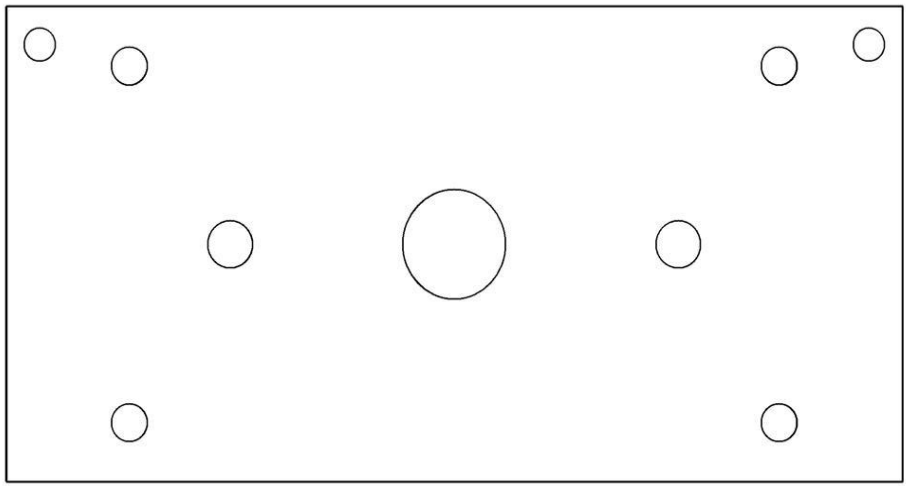


SCALE 0.500

TOOL SUPPORT PLATE

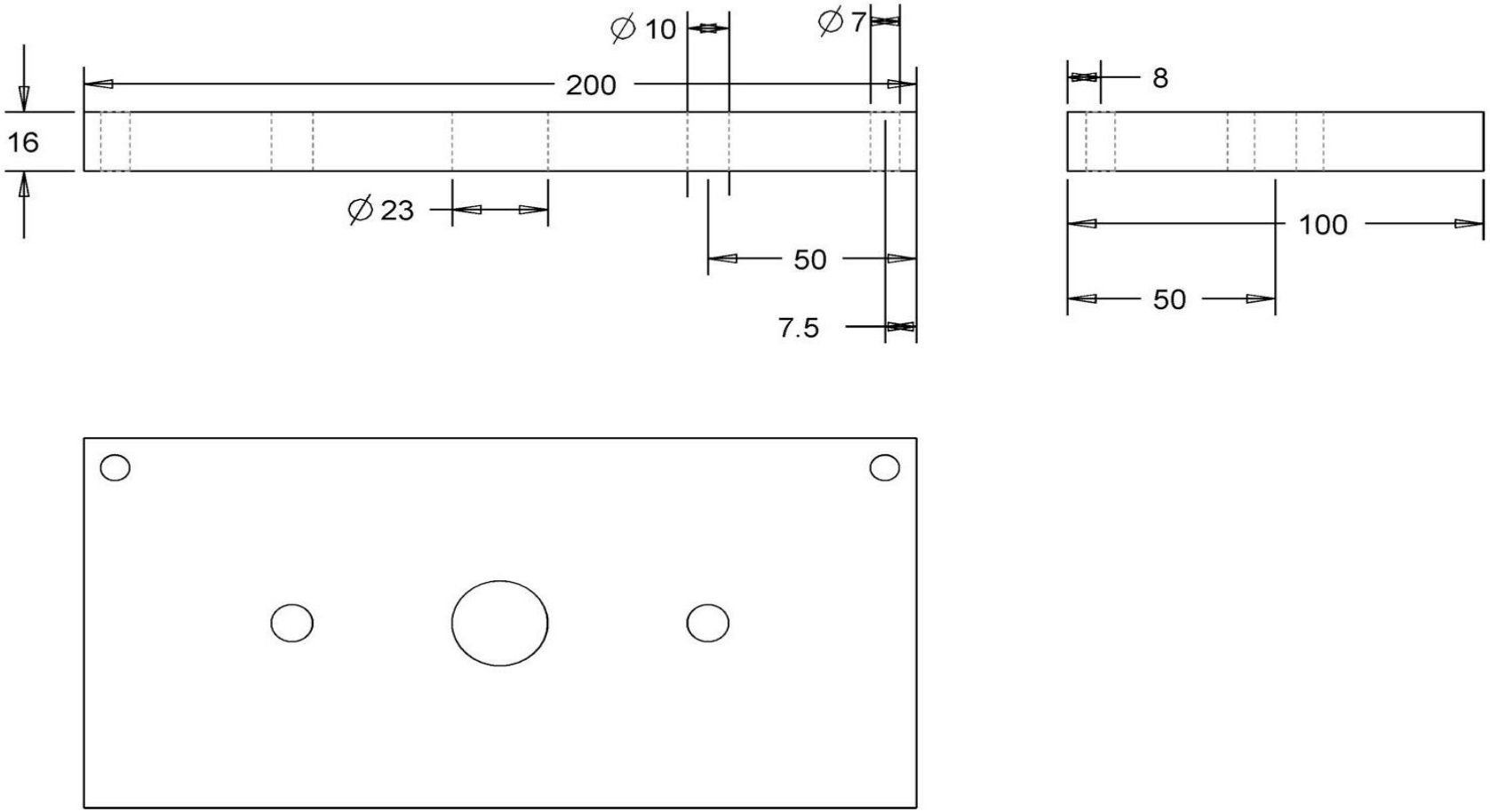






SCALE 0.800

Z-AXIS TOP SUPPORT PLATE



SCALE 0.700

Z-AXIS BOTTOM SUPPORT PLATE

List of Elements

Sr. No.	Material Name	No. Of Parts	Price
1	Stepper motor	3	24926
2	Lead Screw	3	11250
3	MS Plate(Body)	1	22230
4	Cutting charge	-	2430
5	Square Pipe	12	800
6	Drill Machine	1	7928
7	6202 Bearing	6	
8	LM-2 Bearing	12	
9	Tie Rod	6	6270
10	Brass Nut	3	2740
11	Bearing Housing	12	9876
12	Bearing Flange	6	3350
13	Powder coating	-	3900
14	Love Joy Coupling	3	450
15	LN Keys & Nut		1750
16	Fabrication charge		26884
17	Controller board	1	8000
18	Power supply	1	1000
19	wire	60 m	700
20	Carriage Charge		2500

Conclusion

- Development of CNC milling machine is an outstanding contribution to the manufacturing industries. It has made possible the automation of the machining processes with flexibility to handle small to medium batch quantities in part production.
- At present Indian industries needs CNC machines, which facing competition in global market, due to day by day uncertainties in customer demand requirements in term of huge variety of products with better quality and at lesser time. CNC milling machines are best suitable for better accuracy and less man power.

1. The objective to acquaint students with NC programming and CNC milling Machine has been achieved.

2. From this experiment, we can see that NC programming and CNC milling machine help a lot especially in milling process.

3. Milling machines are being replaced rapidly by this CNC Machines (computer numerical-control machines) , which are more versatile and have capable of milling, drilling, boring and also tapping with repetitive accuracy.

4. Milling process will be more easily and less time has been taken to complete the process.

5. Other than that, this machine has the ability to produce complex shapes with high dimensional accuracy besides it can reduce the scrap loss.

Work plan


Task name
August
September
October
November
December
January
February
March
Find out the problem In CNC milling machine
Gather information of machine parts and it's function
Solve the problem of CNC milling machine
Generate software drawing
Order machine parts
Assemble all machine parts
Generate software in visual basic 6.0
Develop interfacing software
Final assembly
Run the machine

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Thank you