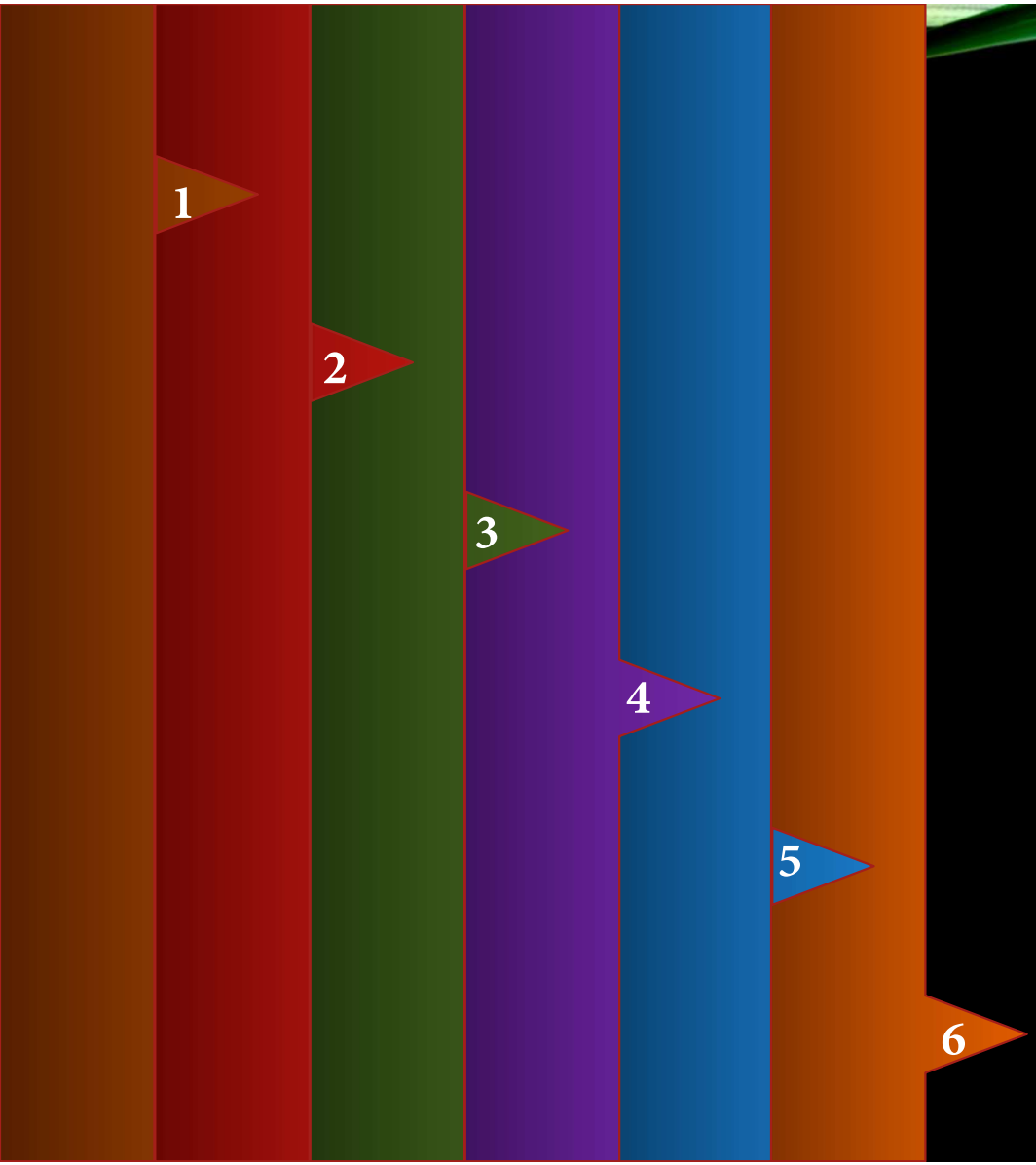
AE 224 : MACHINING SCIENCE AND TECHNOLOGY
AE 242 : METROLOGY

HOUSING DESIGN

SHINGALA VAIDIK PARESHBHAI
(SC21B054)

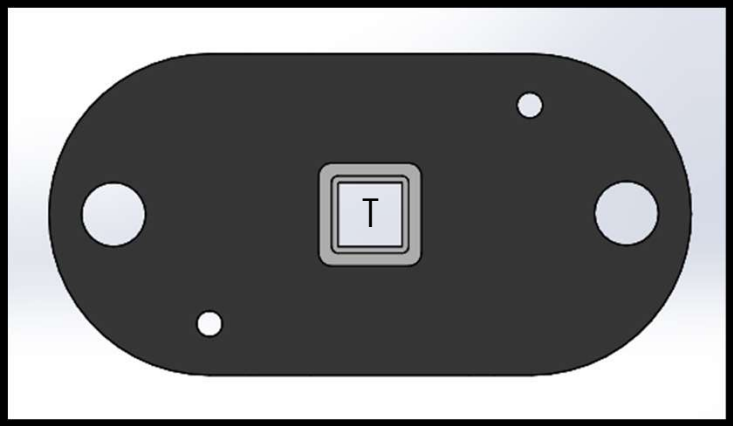


CONTEXT

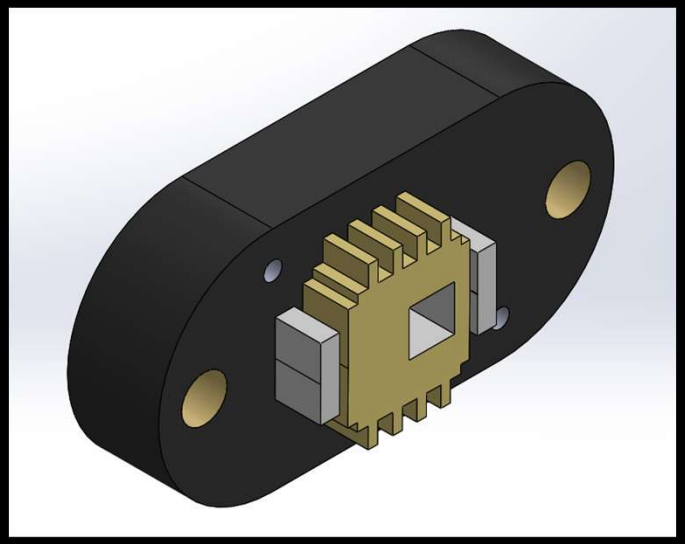
1. SENSORS
2. TOP HOUSING
3. BOTTOM HOUSING
4. SEQUENCE OF MACHINING
5. METROLOGY REQUIREMENTS
6. ASSEMBLY VIDEO/PICTURES

SENSOR

SENSOR ASSEMBLY 1



TOP VIEW



ISOMETRIC VIEW

Weight : 180 gm

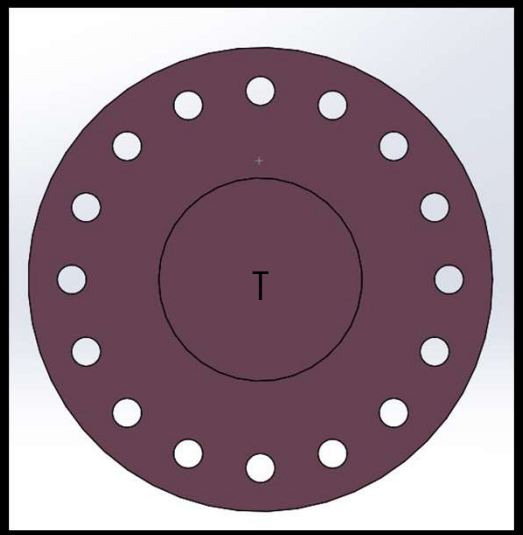
Max. Length : 25mm

Max. Breadth : 50mm

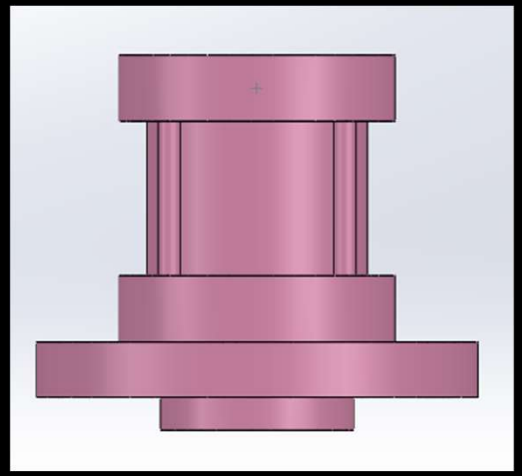
Max. Height : 15mm

T Should be visible in Top view of assembly

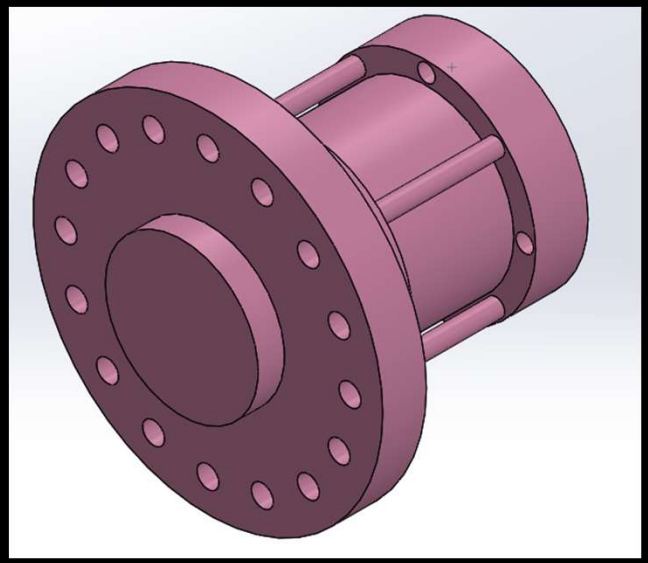
SENSOR ASSEMBLY 2



TOP VIEW



FRONT VIEW



ISOMETRIC VIEW

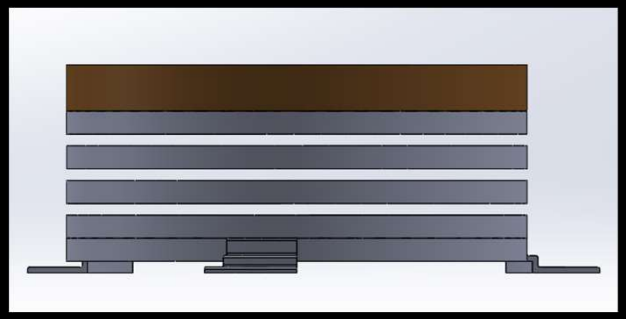
Weight : 210 gm

Max. Diameter : 80mm

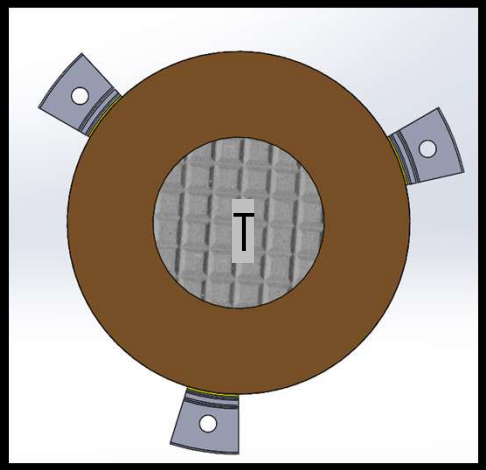
Max. Height : 70mm

T Should be visible in Top view of assembly

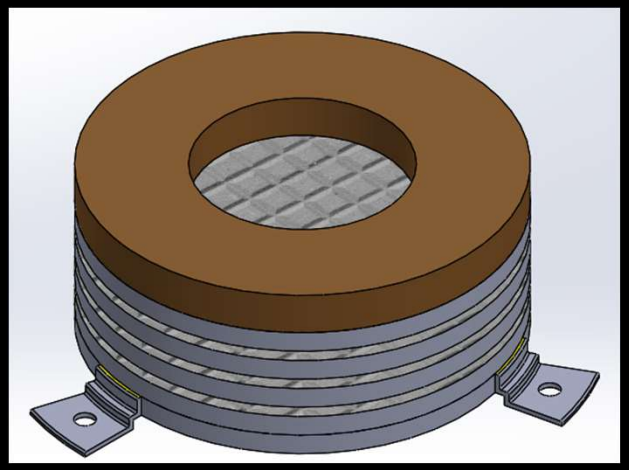
SENSOR ASSEMBLY 3



TOP VIEW



FRONT VIEW



ISOMETRIC VIEW

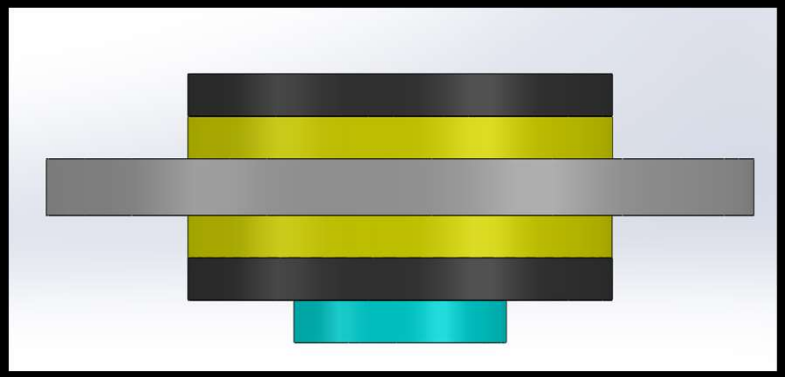
Weight : 160 gm

Max. Diameter : 47.2mm

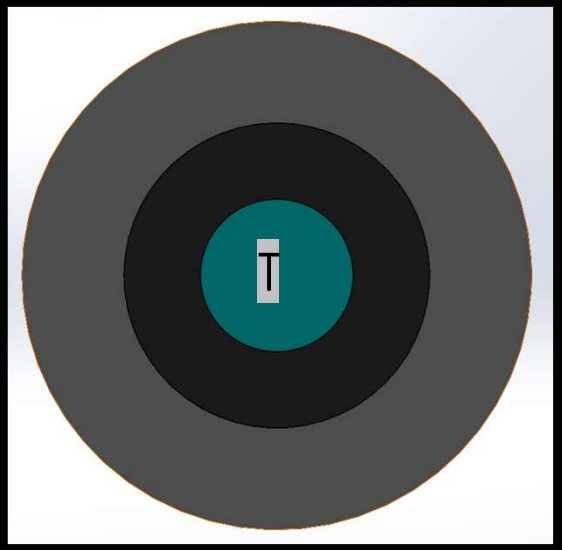
Max. Height : 17mm

T Should be visible in Top view of assembly

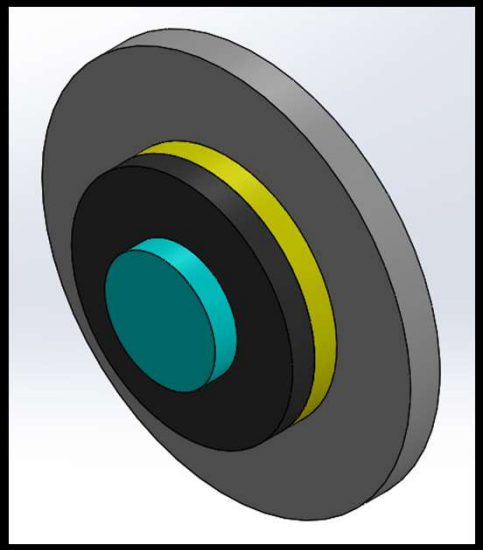
SENSOR ASSEMBLY 4



TOP VIEW



FRONT VIEW



ISOMETRIC VIEW

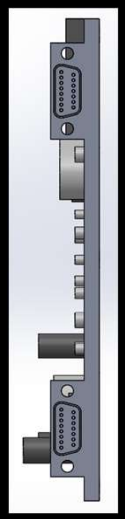
Weight : 180 gm

Max. Diameter : 50mm

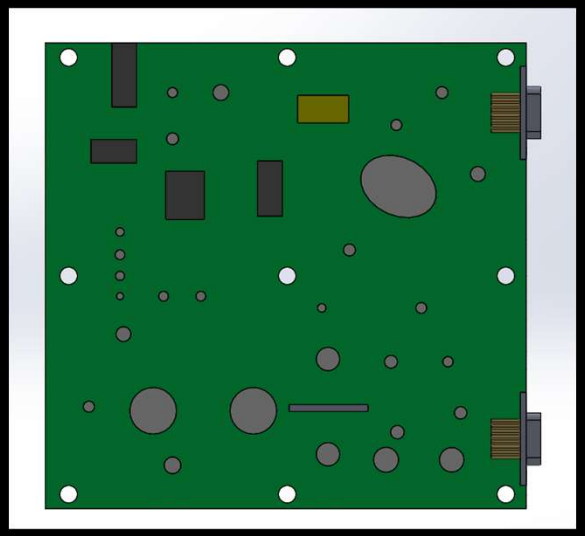
Max. Height : 19mm

T Should be visible in Top view of assembly

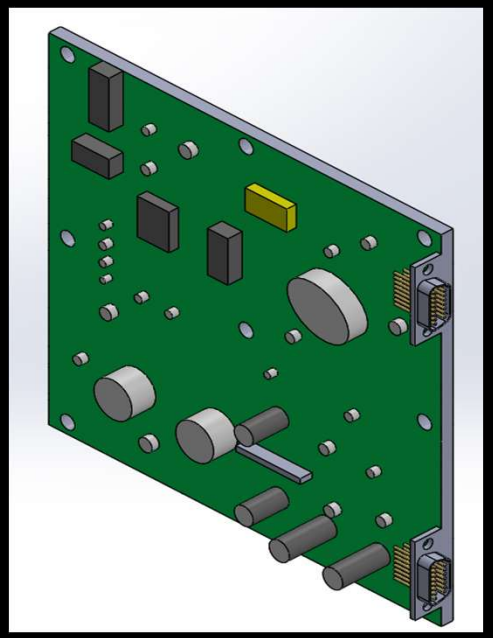
SENSOR ASSEMBLY 5



RIGHT VIEW



TOP VIEW



ISOMETRIC VIEW

Weight : 250 gm

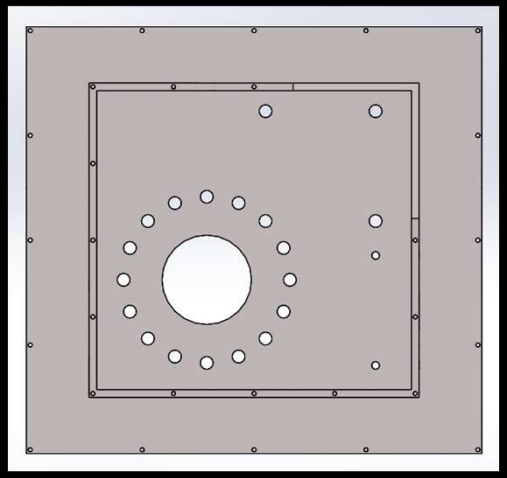
Max. Length : 160mm

Max. Breadth : 170mm

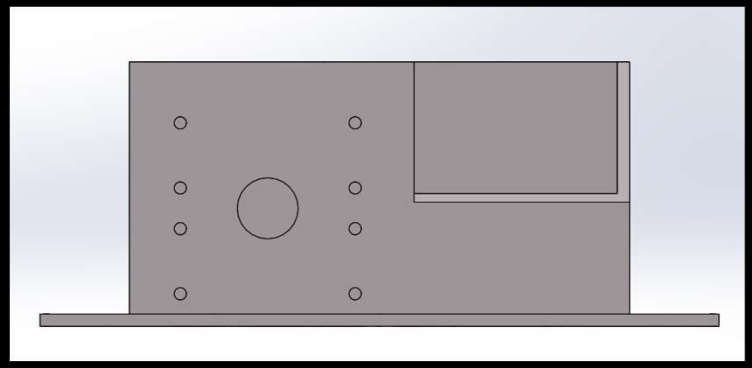
Max. Height : 25mm

TOP HOUSING

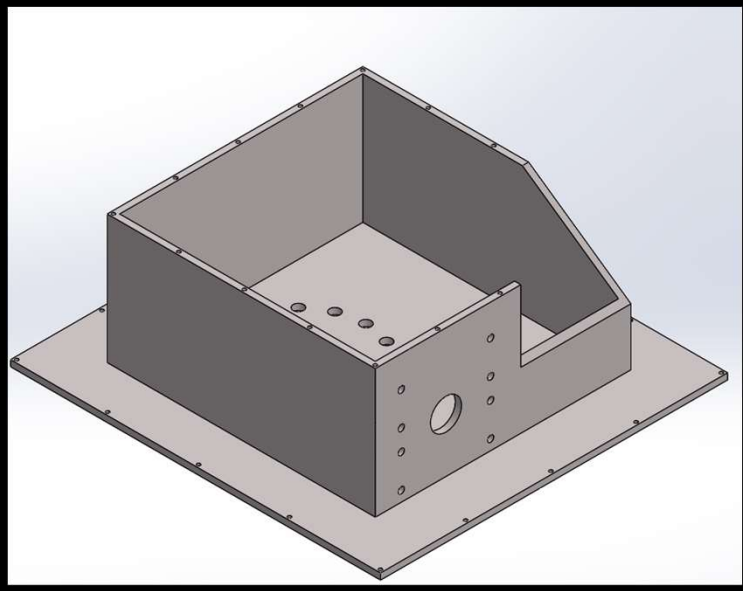
TOP PART 1



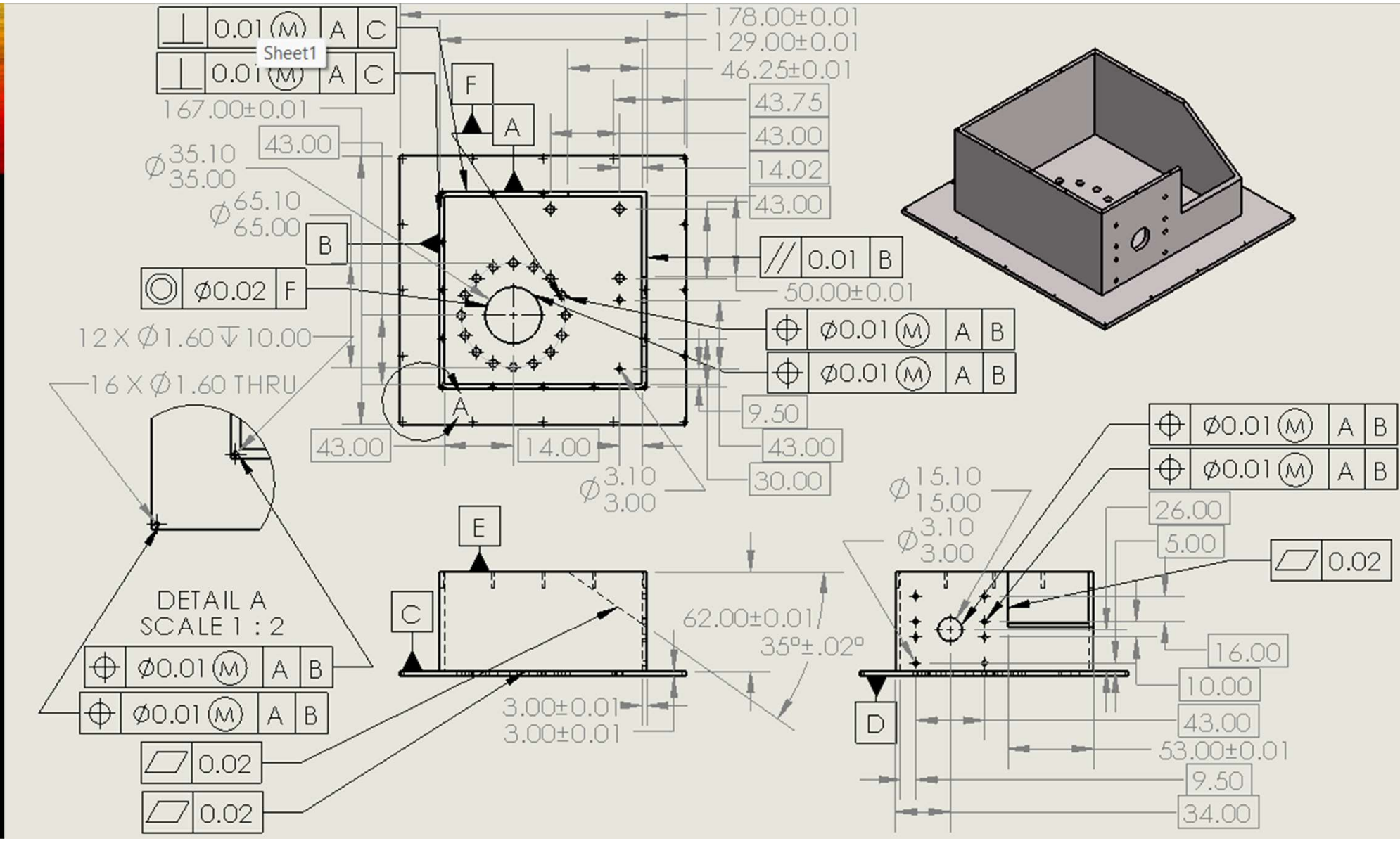
TOP VIEW



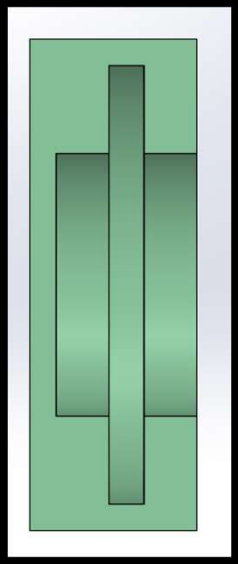
FRONT VIEW



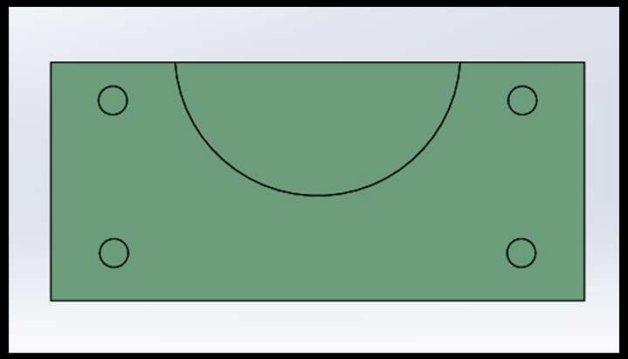
ISOMETRIC VIEW


Sheet1
⊥ 0.01 M A C
⊥ 0.01 M A C
167.00±0.01
43.00
Ø35.10
35.00
Ø65.10
65.00
B
◎ Ø0.02 F
12 X Ø1.60 ↧ 10.00
16 X Ø1.60 THRU
DETAIL A
SCALE 1 : 2
⌖ Ø0.01 M A B
⌖ Ø0.01 M A B
▱ 0.02
▱ 0.02
F
A
178.00±0.01
129.00±0.01
46.25±0.01
43.75
43.00
14.02
43.00
// 0.01 B
50.00±0.01
⌖ Ø0.01 M A B
⌖ Ø0.01 M A B
9.50
43.00
30.00
43.00
14.00
Ø3.10
3.00
E
C
62.00±0.01
35°±.02°
3.00±0.01
3.00±0.01
Ø15.10
15.00
Ø3.10
3.00
⌖ Ø0.01 M A B
⌖ Ø0.01 M A B
26.00
5.00
▱ 0.02
16.00
10.00
43.00
53.00±0.01
9.50
34.00
D

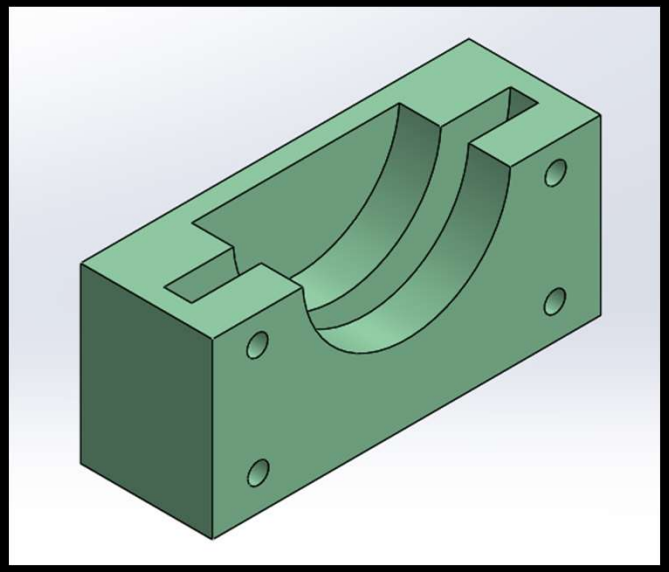
TOP PART 2



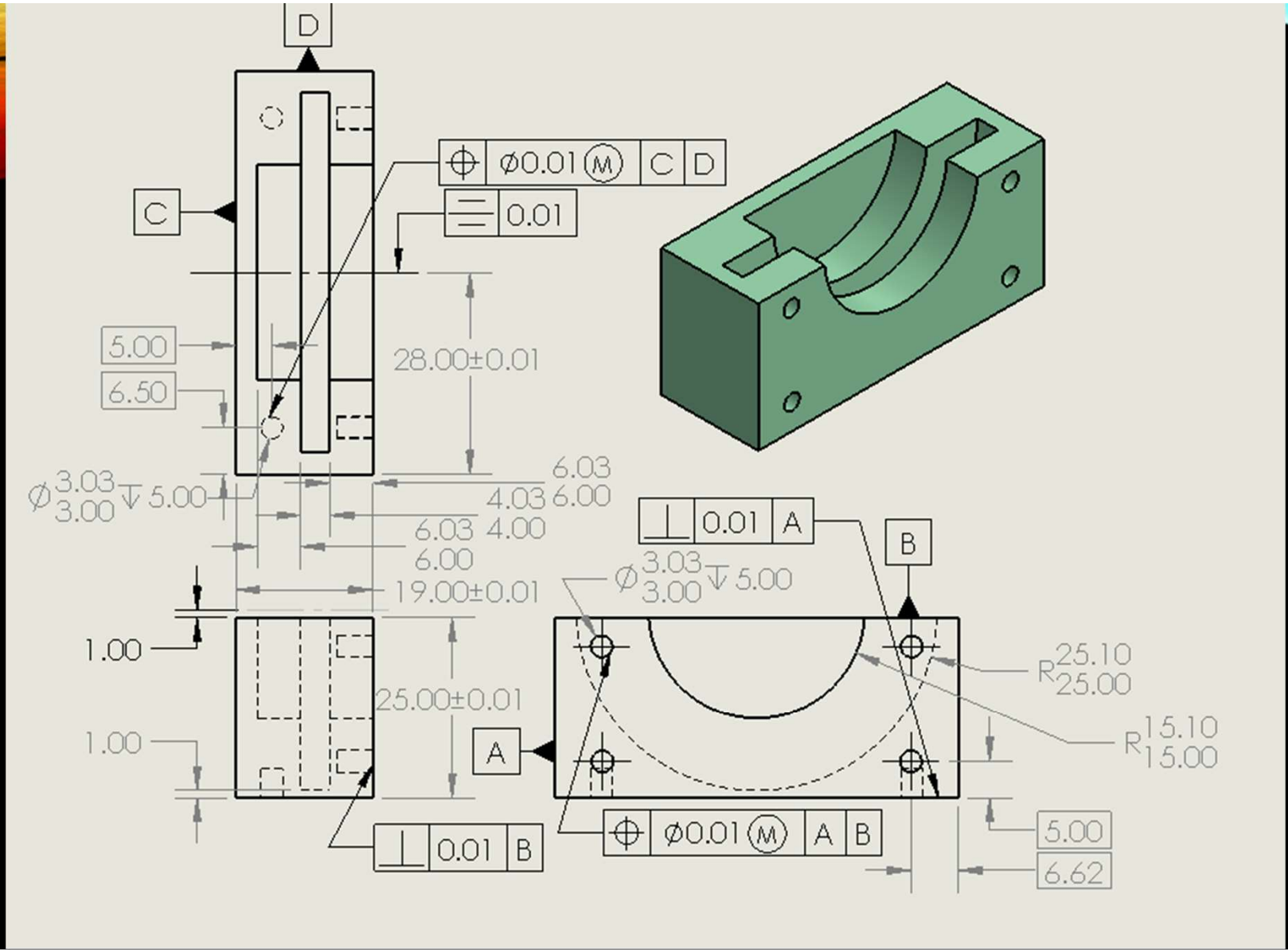
TOP VIEW



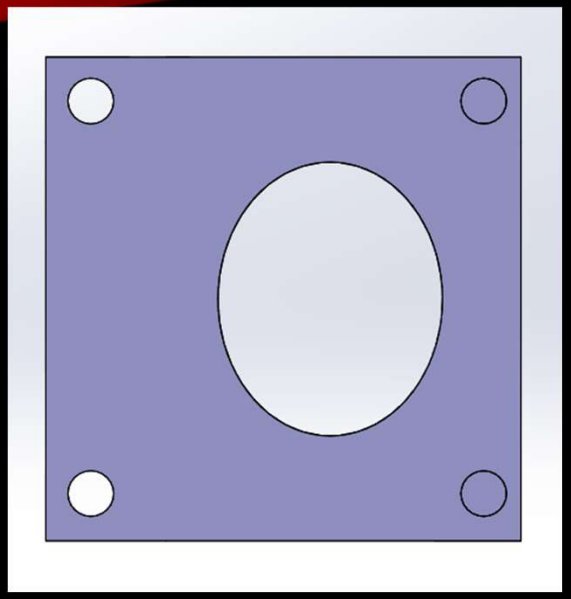
FRONT VIEW



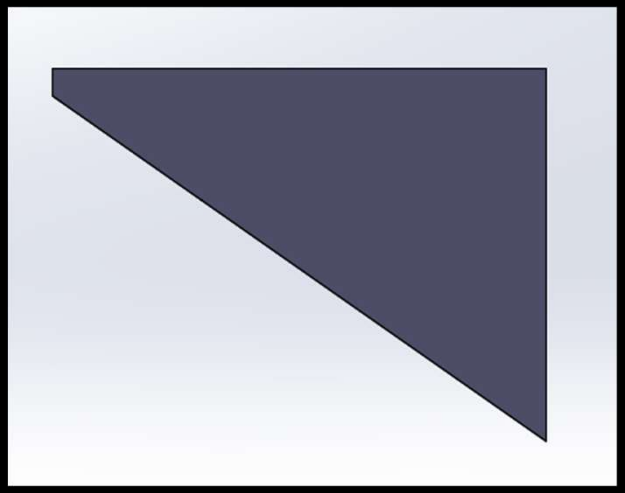
ISOMETRIC VIEW


D
C
Ø0.01 M C D
0.01
5.00
6.50
28.00±0.01
Ø3.03 ↧ 3.00 5.00
6.03
4.03
6.00
6.03
4.00
6.00
19.00±0.01
1.00
1.00
25.00±0.01
A
0.01 B
0.01 A
B
Ø3.03 ↧ 3.00 5.00
R25.10
25.00
R15.10
15.00
Ø0.01 M A B
5.00
6.62

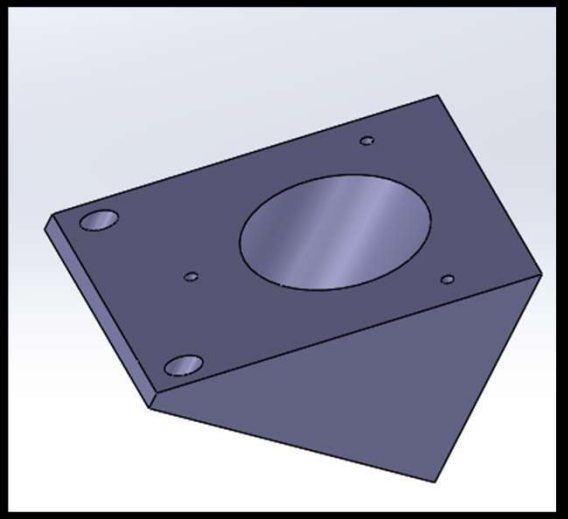
TOP PART 3



TOP VIEW

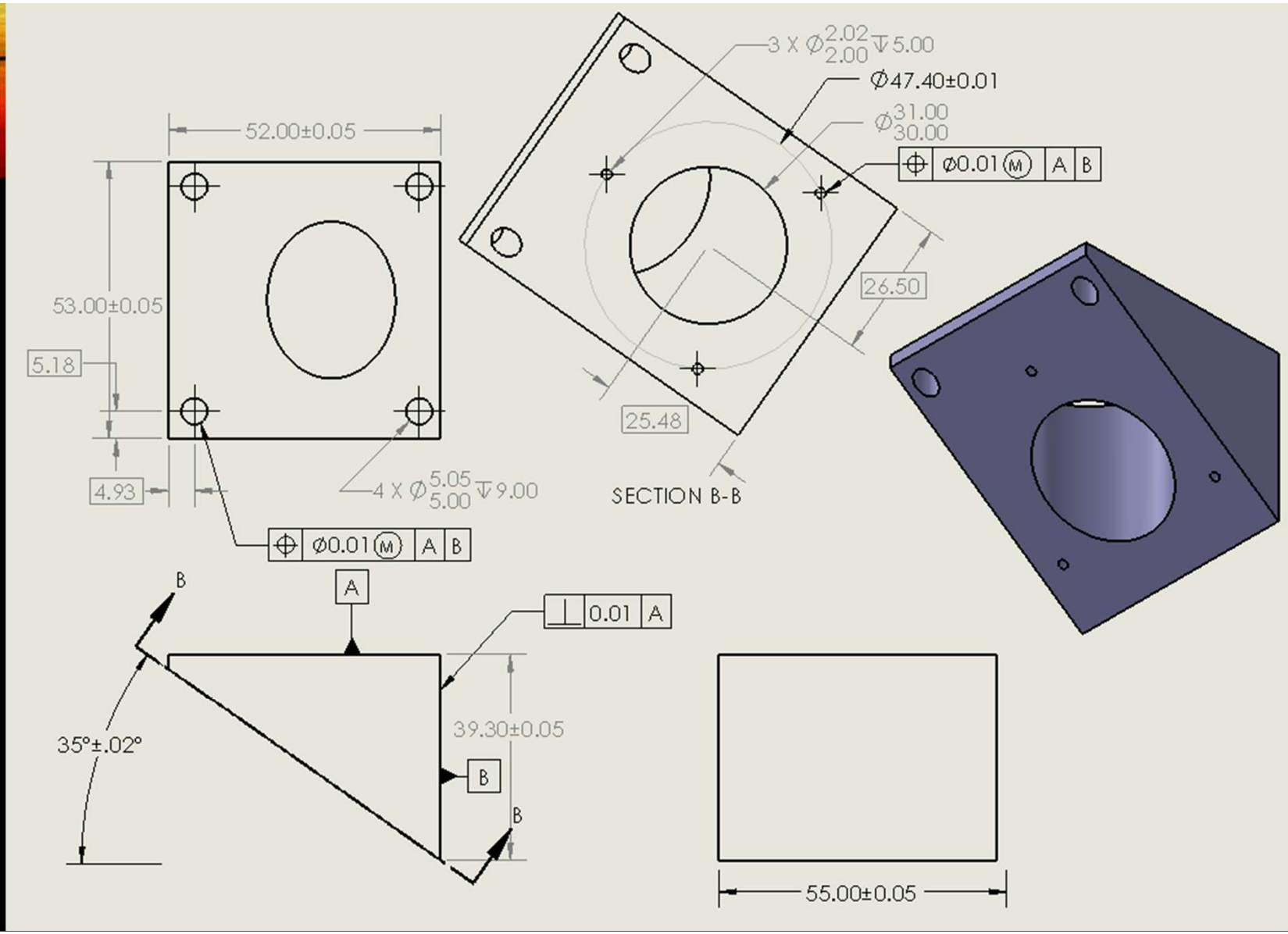


FRONT VIEW

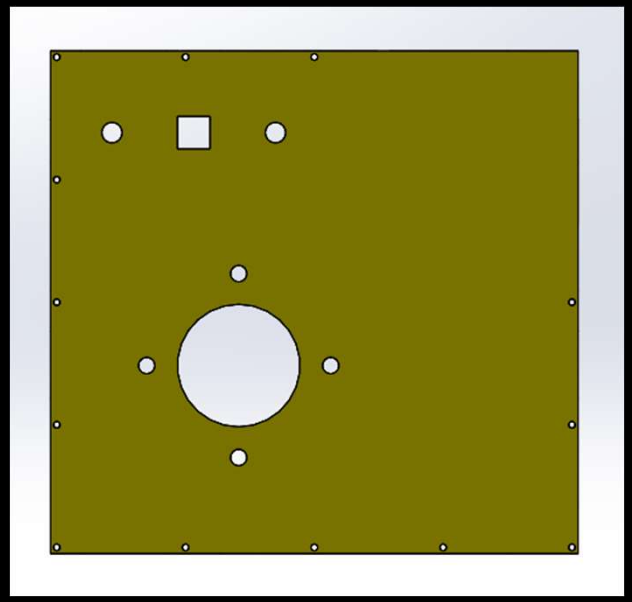


ISOMETRIC VIEW

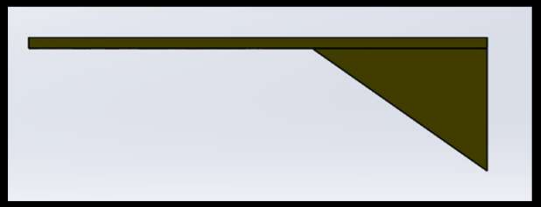
Make a inner circle for reducing weight


52.00±0.05
53.00±0.05
5.18
4.93
4 X Ø5.05 5.00 ↧9.00
Ø0.01 M A B
3 X Ø2.02 2.00 ↧5.00
Ø47.40±0.01
Ø31.00 30.00
Ø0.01 M A B
26.50
25.48
SECTION B-B
A
0.01 A
B
35°±.02°
39.30±0.05
B
B
55.00±0.05

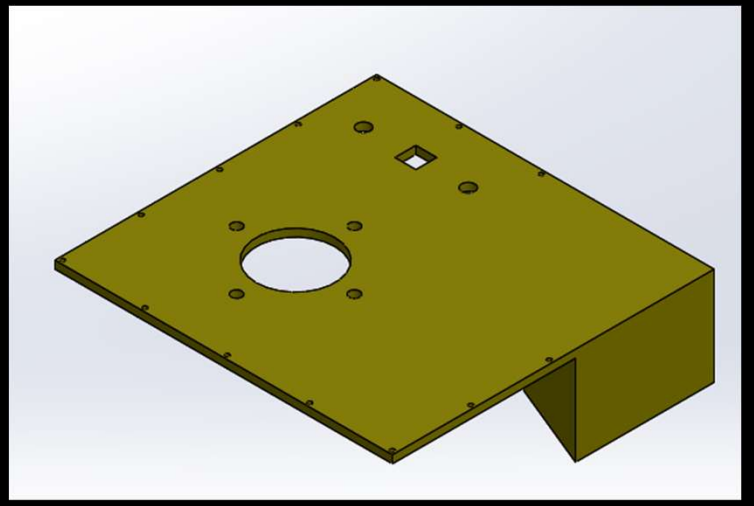
TOP PART 4



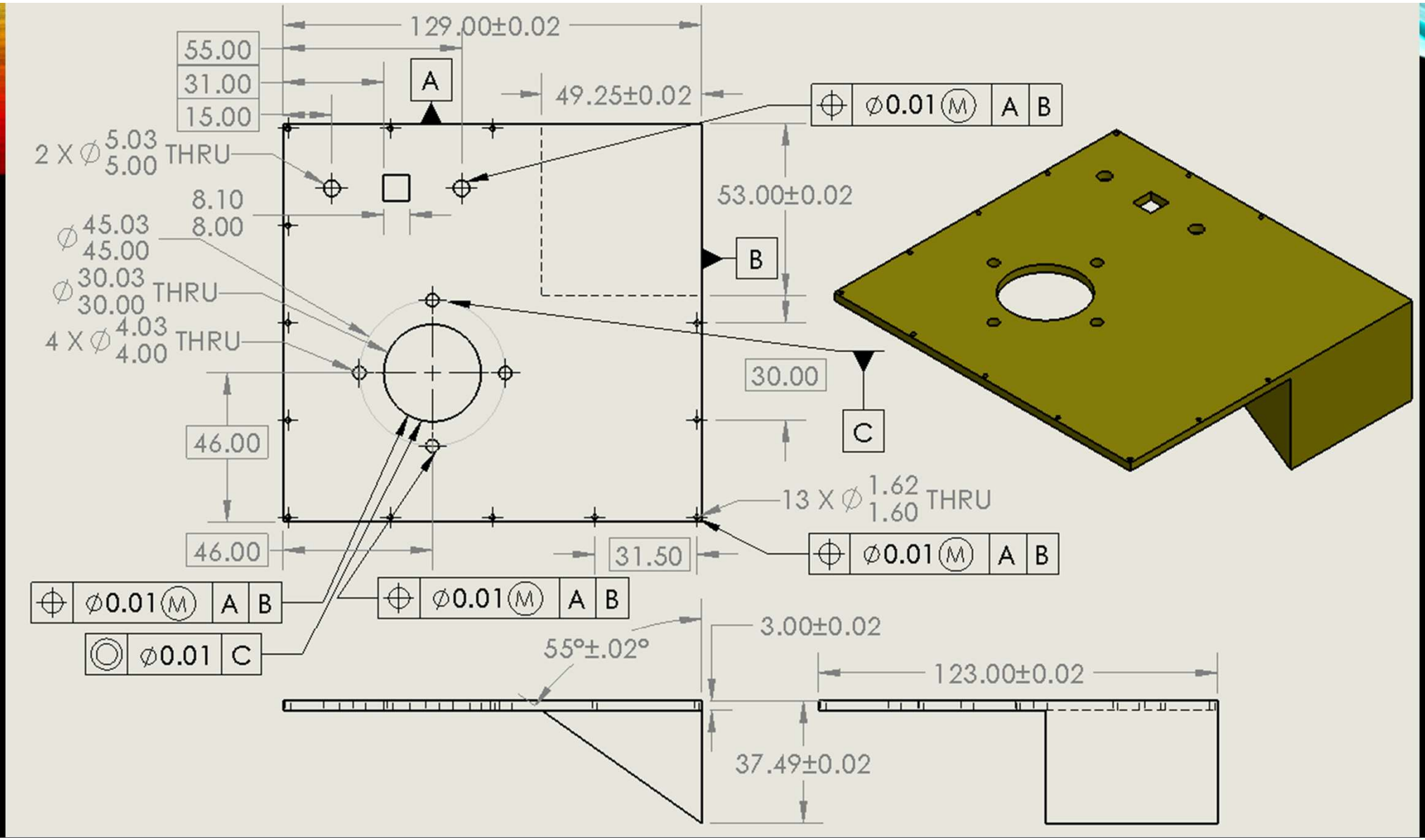
TOP VIEW



FRONT VIEW

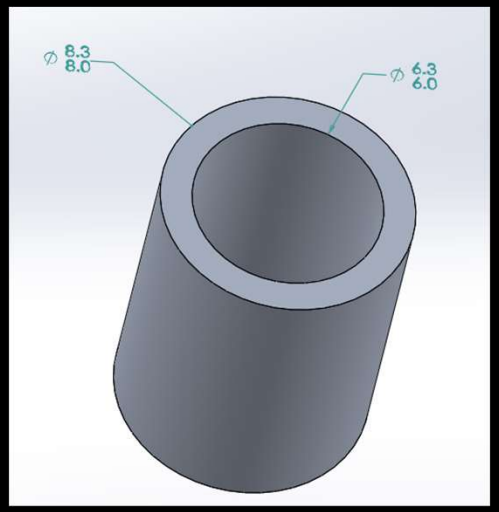


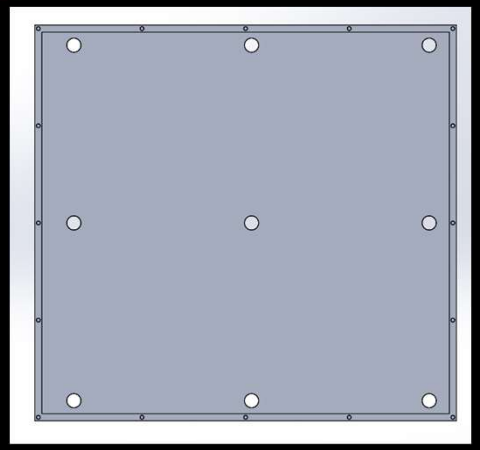
ISOMETRIC VIEW


129.00±0.02
55.00
31.00
15.00
A
49.25±0.02
⌖ ∅0.01 Ⓜ A B
2 X ∅5.03 5.00 THRU
8.10
8.00
∅45.03 45.00
∅30.03 30.00 THRU
4 X ∅4.03 4.00 THRU
53.00±0.02
B
30.00
C
46.00
46.00
13 X ∅1.62 1.60 THRU
⌖ ∅0.01 Ⓜ A B
31.50
⌖ ∅0.01 Ⓜ A B
⌖ ∅0.01 Ⓜ A B
◎ ∅0.01 C
55°±.02°
3.00±0.02
123.00±0.02
37.49±0.02

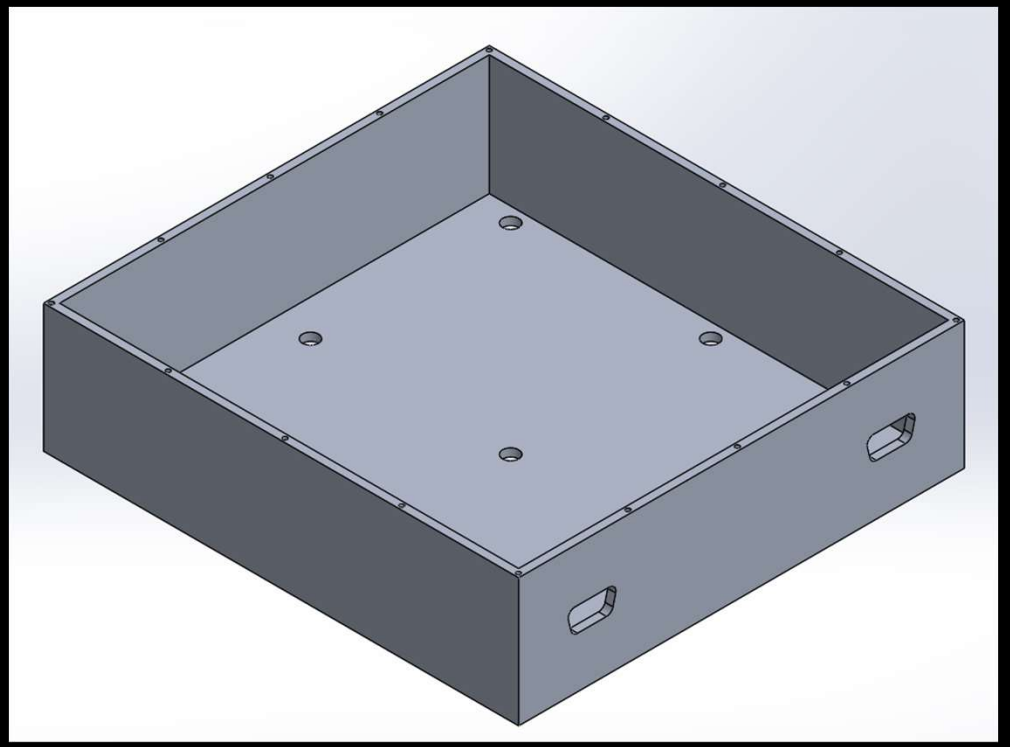
BOTTOM HOUSING

EXTRA PART : Height 10mm

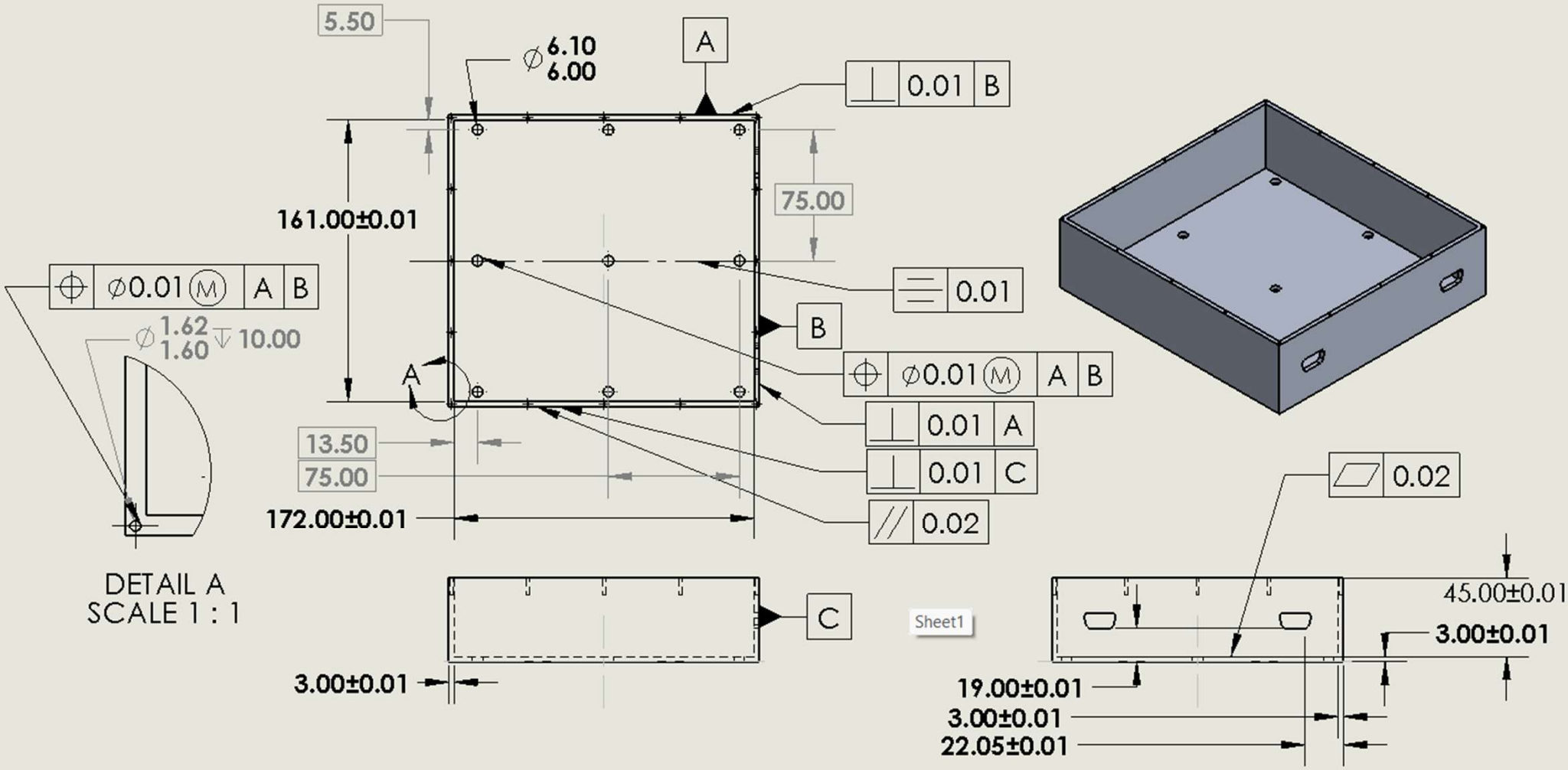




TOP VIEW



ISOMETRIC VIEW


5.50
∅6.10
6.00
A
0.01 B
161.00±0.01
75.00
0.01
B
∅0.01 M A B
∅1.62
1.60
10.00
A
13.50
75.00
172.00±0.01
0.01 A
0.01 C
0.02
DETAIL A
SCALE 1 : 1
C
3.00±0.01
Sheet1
0.02
45.00±0.01
3.00±0.01
19.00±0.01
3.00±0.01
22.05±0.01

Mass analysis

1. Top Part 1 – 453.66 gm
2. Top Part 2 – 2 x 50.74 gm
3. Top Part 3 – 116.63 gm
4. Top Part 4 – 242.86 gm
5. Bottom Part – 482.66 gm
6. Extra Part – 10 x 0.6 gm
7. Fastener – 100 gm (around)
8. Sensor – 980 gm

Total Mass = 2433.29 gm = 2.433 kg

Given Screenshot in next slide as reference

Assembly 1 (Default) <<Default>_Di
- History
- Sensors
- Annotations
- Solid Bodies(1)
- 6061 Alloy
- Front Plane
- Top Plane
- Right Plane
- Origin
- Boss-Extrude1
- Boss-Extrude2
- Cut-Extrude1
- Boss-Extrude4
- Cut-Extrude2
- Cut-Extrude3

Create Center of Mass feature

Show weld bead mass

Report coordinate values relative to: -- default --

Mass properties of Assembly 1
Configuration: Default
Coordinate system: -- default --

Density = 0.00 grams per cubic millimeter

Mass = 482.60 grams

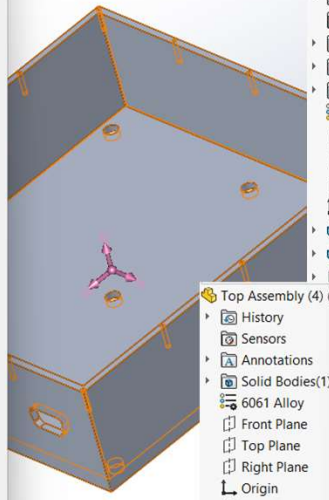
Volume = 178740.04 cubic millimeters

Surface area = 123043.93 square millimeters

Center of mass: (millimeters)
X = -0.44
Y = 13.61
Z = 0.00

Principal axes of inertia and principal moments of inertia: (grams * square millim
Taken at the center of mass.
Ix = (1.00, 0.00, 0.00) Px = 1777270.19
Iy = (0.00, 0.00, -1.00) Py = 1957201.17
Iz = (0.00, 1.00, 0.00) Pz = 3512842.92

Moments of inertia: (grams * square millimeters)
Taken at the center of mass and aligned with the output coordinate system. (Usin
Lxx = 1777272.56 Lxy = -2027.88 Lxz = 0.00
Lyx = -2027.88 Lyy = 3512840.55 Lyz = 0.00
Lzx = 0.00 Lzy = 0.00 Lzz = 1957201.17



Top Assembly (1) (Default) <<Defau
- History
- Sensors
- Annotations
- Solid Bodies(1)
- Markups
- 6061 Alloy
- Front Plane
- Top Plane
- Right Plane
- Origin
- Boss-Extrude1
- Boss-Extrude2
- Cut-Extrude1

Create Center of Mass feature

Show weld bead mass

Report coordinate values relative to: -- default --

Mass properties of Top Assembly (1)
Configuration: Default
Coordinate system: -- default --

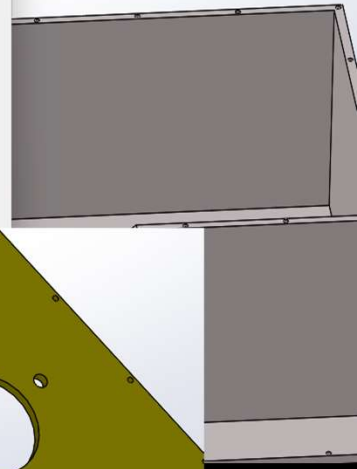
Density = 0.00 grams per cubic millimeter

Mass = 453.66 grams

Volume = 168021.55 cubic millimeters

Surface area = 116965.57 square millimeters

Center of mass: (millimeters)
X = 0.52



Top Assembly (3) (Defa
- History
- Sensors
- Annotations
- Solid Bodies(1)
- Markups
- 6061 Alloy
- Front Plane
- Top Plane
- Right Plane
- Origin
- Boss-Extrude1
- Cut-Extrude2
- (-) Sketch14
- Boss-Extrude2
- Cut-Extrude3
- Cut-Extrude4
- Cut-Extrude5
- Cut-Extrude6

Show weld bead mass

Report coordinate values relative to: -- default --

Mass properties of Top Assembly (3)
Configuration: Default
Coordinate system: -- default --

Density = 0.00 grams per cubic millimeter

Mass = 50.74 grams

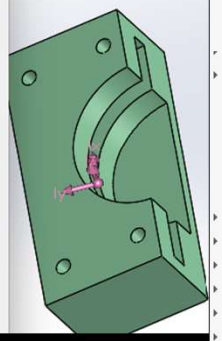
Volume = 18793.62 cubic millimeters

Surface area = 7647.10 square millimeters

Center of mass: (millimeters)
X = -0.65
Y = 10.70
Z = 0.00

Principal axes of inertia and principal moments of inertia: (grams * square millim
Taken at the center of mass.
Ix = (0.00, 0.00, 1.00) Px = 4239.46
Iy = (0.26, -0.97, 0.00) Py = 18115.01
Iz = (0.97, 0.26, 0.00) Pz = 18938.36

Moments of inertia: (grams * square millimeters)
Taken at the center of mass and aligned with the output coordinate system. (Usin
Lxx = 18882.78 Lxy = -206.57 Lxz = 0.00



Top Assembly (4) (Defa
- History
- Sensors
- Annotations
- Solid Bodies(1)
- 6061 Alloy
- Front Plane
- Top Plane
- Right Plane
- Origin
- Boss-Extrude1
- Cut-Extrude1
- Cut-Extrude2
- Cut-Extrude3
- Cut-Extrude4
- Boss-Extrude2

Create Center of Mass feature

Show weld bead mass

Report coordinate values relative to: -- default --

Mass properties of Top Assembly (4)
Configuration: Default
Coordinate system: -- default --

Density = 0.00 grams per cubic millimeter

Mass = 242.86 grams

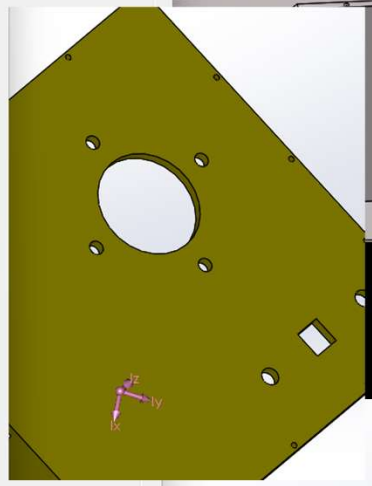
Volume = 89948.93 cubic millimeters

Surface area = 36395.15 square millimeters

Center of mass: (millimeters)
X = 24.64
Y = -5.00
Z = -17.77

Principal axes of inertia and principal moments of inertia: (grams * square millim
Taken at the center of mass.
Ix = (0.81, -0.13, -0.58) Px = 200275.02
Iy = (-0.58, 0.02, -0.81) Py = 412699.67
Iz = (0.12, 0.99, -0.06) Pz = 589700.47

Moments of inertia: (grams * square millimeters)
Taken at the center of mass and aligned with the output coordinate system. (Usin
Lxx = 277158.95 Lxy = -42756.06 Lxz = -97556.80



Annotations
- Solid Bodies(1)
- 6061 Alloy
- Front Plane
- Top Plane
- Right Plane
- Origin
- Boss-Extrude1
- Cut-Extrude1
- Cut-Extrude2
- Cut-Extrude6
- Cut-Extrude7
- Cut-Extrude8
- Cut-Extrude9

Mass properties of Top Assembly (2)
Configuration: Default
Coordinate system: -- default --

Density = 0.00 grams per cubic millimeter

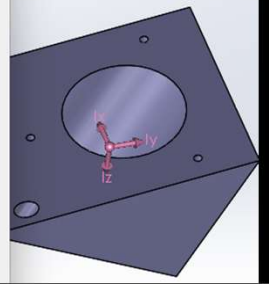
Mass = 116.63 grams

Volume = 43194.51 cubic millimeters

Surface area = 11874.66 square millimeters

Center of mass: (millimeters)
X = 7.45
Y = 26.57
Z = 0.00

Principal axes of inertia and principal moments of inertia: (grams * square millim
Taken at the center of mass.
Ix = (0.00, 0.00, 1.00) Px = 35237.76
Iy = (0.90, -0.44, 0.00) Py = 40426.72
Iz = (0.44, 0.90, 0.00) Pz = 62376.83



NO OF PART REQUIREMENTS

1. Top Part 1 – 1 No.
2. Top Part 2 – 2 No.
3. Top Part 3 – 1 No.
4. Top Part 4 – 1 No.
5. Bottom Part – 1 No.
6. Extra Part – 10 No.
7. We will use bolt and nut wherever there is through hole and screw wherever there is blind hole of respective diameter of holes.

SEQUENCE OF MACHINING

WHY I CHOSE ALUMINUM 6061

- Aluminum has many advantages, being lightweight, easy to machine, non-magnetic, corrosion resistant and inexpensive. Aluminum is even becoming a preferred choice to steel, with advances in cleaning and machining to make aluminum a more useful material.
- Aluminum is known for its versatility; while properties such as superb resistance to corrosion and excellent thermal conductivity are very useful in many applications, it is the flexibility and adaptability of aluminum's mechanical properties that make it such a widely used metal.

Property	Value	Units
Elastic Modulus	69000	N/mm^2
Poisson's Ratio	0.33	N/A
Shear Modulus	26000	N/mm^2
Mass Density	2700	kg/m^3
Tensile Strength	124.084	N/mm^2
Compressive Strength		N/mm^2
Yield Strength	55.1485	N/mm^2
Thermal Expansion Coefficient	2.4e-05	/K
Thermal Conductivity	170	W/(m·K)
Specific Heat	1300	J/(kg·K)

Composition:

Element	Amount (wt %)
Aluminium	96.85
Magnesium	0.9
Silicon	0.7
Iron	0.6
Copper	0.30
Chromium	0.25
Zinc	0.20
Titanium	0.10
Manganese	0.05
Others	0.05

Sequence of machining operation

Take two block of dimension (A) 260 x 180 x 80 mm and (B) 200 x 200 x 100 mm.

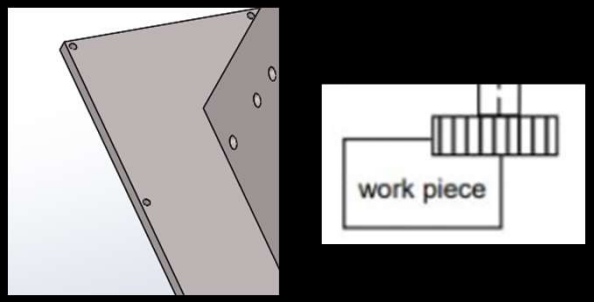
1. Cutting : Now cut (A) block into two part of dimension (A1) 180 x 180 x 70 mm and (A2) 60 x 60 x 45 mm and (A3) 60 x 20 x 30 mm and Cut (B) block into two part of dimension (B1) 180 x 170 x 50 mm and (B2) 135 x 130 x 40 mm.

I am using block (A1) for Top part 1, (A2) for Top part 3, (A3) for Top part 2, (B1) for Bottom part, (B2) for Top part 4.

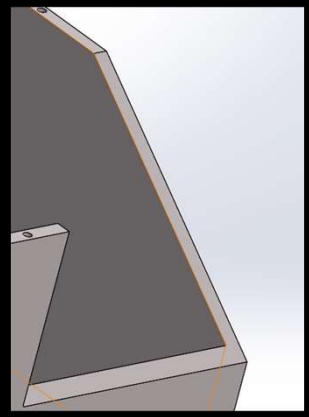
2. Face Milling : Now remove extra material from (A1) to make cuboid of dimension 179 X 168 X 66mm, (A2) to make cuboid of dimension 53 X 54 X 41mm, (A3) to make cuboid of dimension 57 X 26 X 20mm, (B1) to make cuboid of dimension 162 X 173 X 76mm, (B2) to make cuboid of dimension 130 X 124 X 39mm. Extra 1 mm given more because this can be removed by grinding at last for better finishing.

Top part 1 : From (A1) block

1. Partial Face Milling : To remove material from all four edges of required depth and width from top to make the strips at bottom.
2. Form Milling : Used to make the 35° inclined face from the top. This can either be done by making a jig of required shape such that the inclined face becomes horizontal. Then raw material is fixed to the jig and material can be removed by peripheral milling.
3. End milling : material is cut out to make it hollow. Such that wall thickness should be 4 mm (extra 1 mm will be removed at last by grinding for surface finish).
4. Drilling : All the holes are drilled using drilling machine with drill bit of available size and then by boring process to enlarge it of required dimensions.



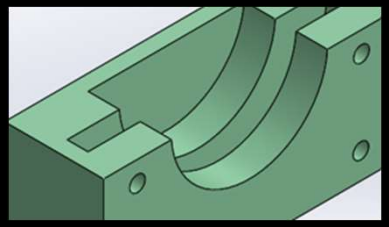
Partial Face Milling



Form Milling With Jig

Top part 3 : From (A2) block

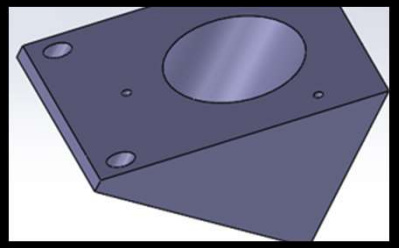
1. Drilling : All the holes are drilled using drilling machine with drill bit of available size and then by boring process to enlarge it of required dimensions.
2. CNC End Milling : To Make circular profile hole



CNC End Milling

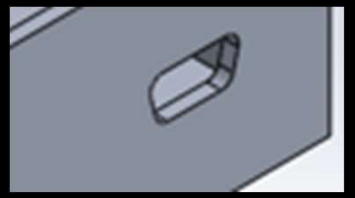
Top part 2 : From (A3) block

1. Form Milling : Used to make the 35° inclined face from the top. This can either be done by making a jig of required shape such that the inclined face becomes horizontal. Then raw material is fixed to the jig and material can be removed by peripheral milling.
2. Drilling : All the holes are drilled using drilling machine with drill bit of available size and then by boring process to enlarge it of required dimensions.



Bottom part : From (B1) block

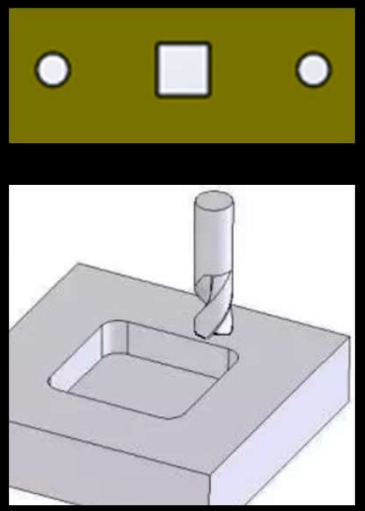
1. End milling : material is cut out to make it hollow. Such that wall thickness should be 4 mm (extra 1 mm will be removed at last by grinding for surface finish).
2. Drilling : All the holes are drilled using drilling machine with drill bit of available size and then by boring process to enlarge it of required dimensions.



This D-pin hole can be made by Peripheral Milling

Top part 4: From (B2) block

1. End milling : material is cut out to make it hollow. Such that wall thickness should be 4 mm (extra 1 mm will be removed at last by grinding for surface finish).
2. Form Milling : Used to make the 35° inclined face from the top. This can either be done by making a jig of required shape such that the inclined face becomes horizontal. Then raw material is fixed to the jig and material can be removed by peripheral milling.
3. Drilling : All the holes are drilled using drilling machine with drill bit of available size and then by boring process to enlarge it of required dimensions.



Peripheral Milling

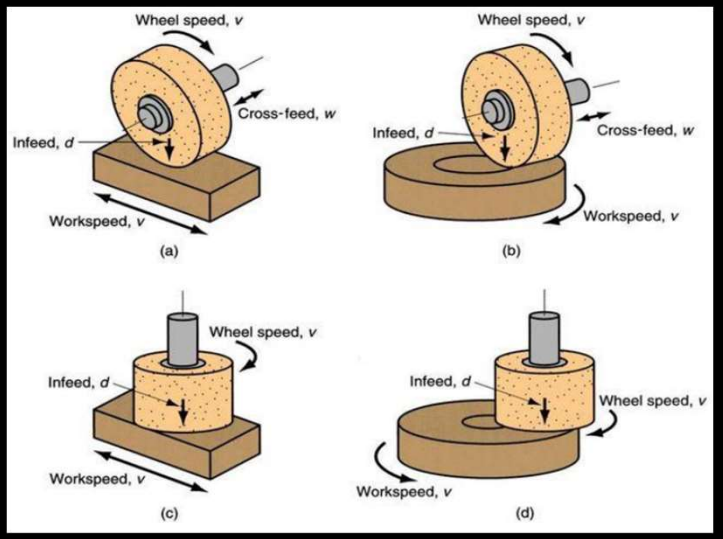
We can use lathe(turning operation) for making Extra Part because it is a cylinder.

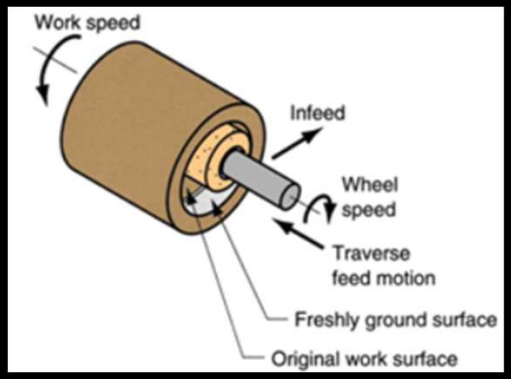
Surface Finishing

1. Grinding : The extra 1 mm left on all the surfaces of upper part removed by grinding in both upper and lower housings.

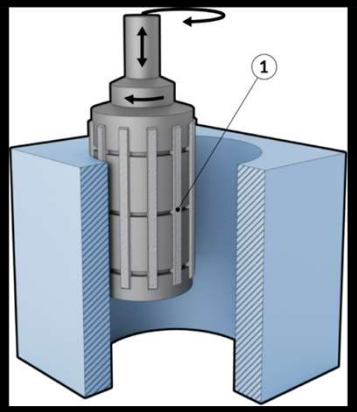
XX C 600 M 4 V YY Grinding wheel can be used.

2. Internal grinding is used for making the inner surfaces of sensor pockets polished (To ensure the easy passing of sensors)



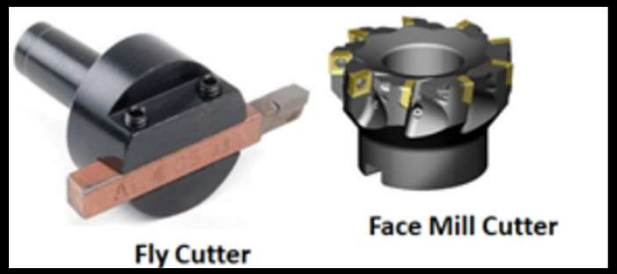


Internal cylinder grinding



Horning

MACHINES USED



UNIVERSAL MILLING MACHINE

DRILLING MACHINE

ANGLE GRINDER

GRINDING WHELL

METROLOGY REQUIREMENTS

1. Straightness : Straightness is measured by observing the color of light by diffraction while passing through the small gap in auto-collimator.

auto-collimator

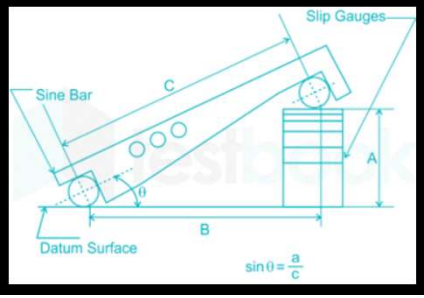
2. Flatness: One of the most important geometric requirements of any design is to measure the flatness tolerance of the design, we can use a comparator to measure this. It has a dial and a very important point for measuring pressure. We can use spirit to measure truth and truth. The only difference is that the scale dial gives the actual reading and the spirit level gives the corresponding reading.

Spirit level

Dial Gauge

3. Dimensional/Positional/symmetric tolerances : We can use a profile projector to project the various tasks and specify their position and size. We can also determine whether geometric and long dimensions are met. The other instruments like vernier-caliper, vernier height gauge, internal micrometers, Telescopic gauge, sine gauge etc. can be used to determine the dimensions in the product.

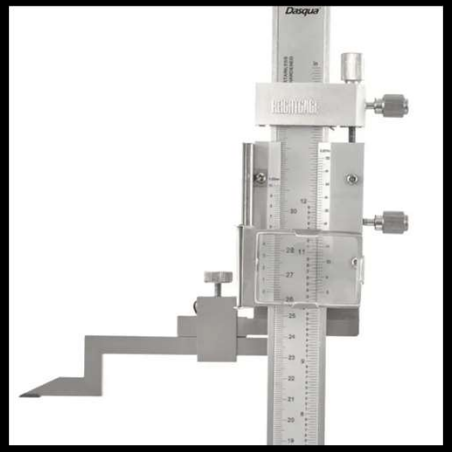
4. Parallelism: Parallelism between two lines/spaces can be multiplied using a calculator. However, we prefer altimeter to measure because it is easy to use.



Sine Gauge

Profile projector

internal micrometers



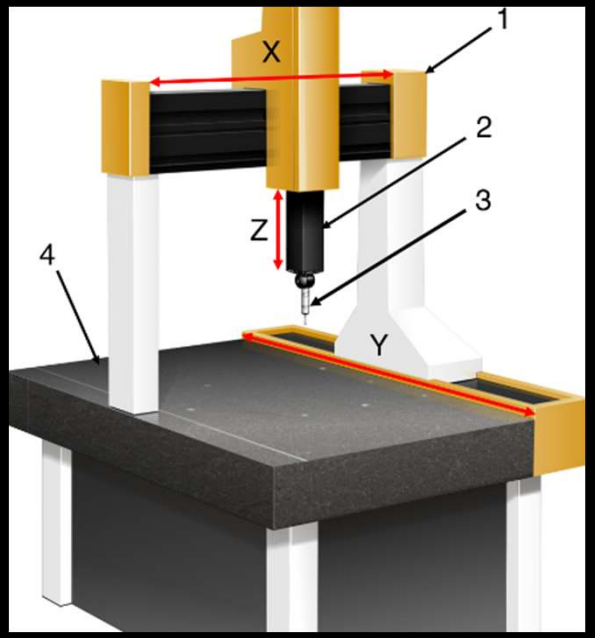
Height Gauge

Vernier Caliper

5. Perpendicularity : Perpendicularity is measured using a height gauge, similar to flatness, however, the gauge (or part) is locked to a 90° datum to measure how perpendicular the surface is.

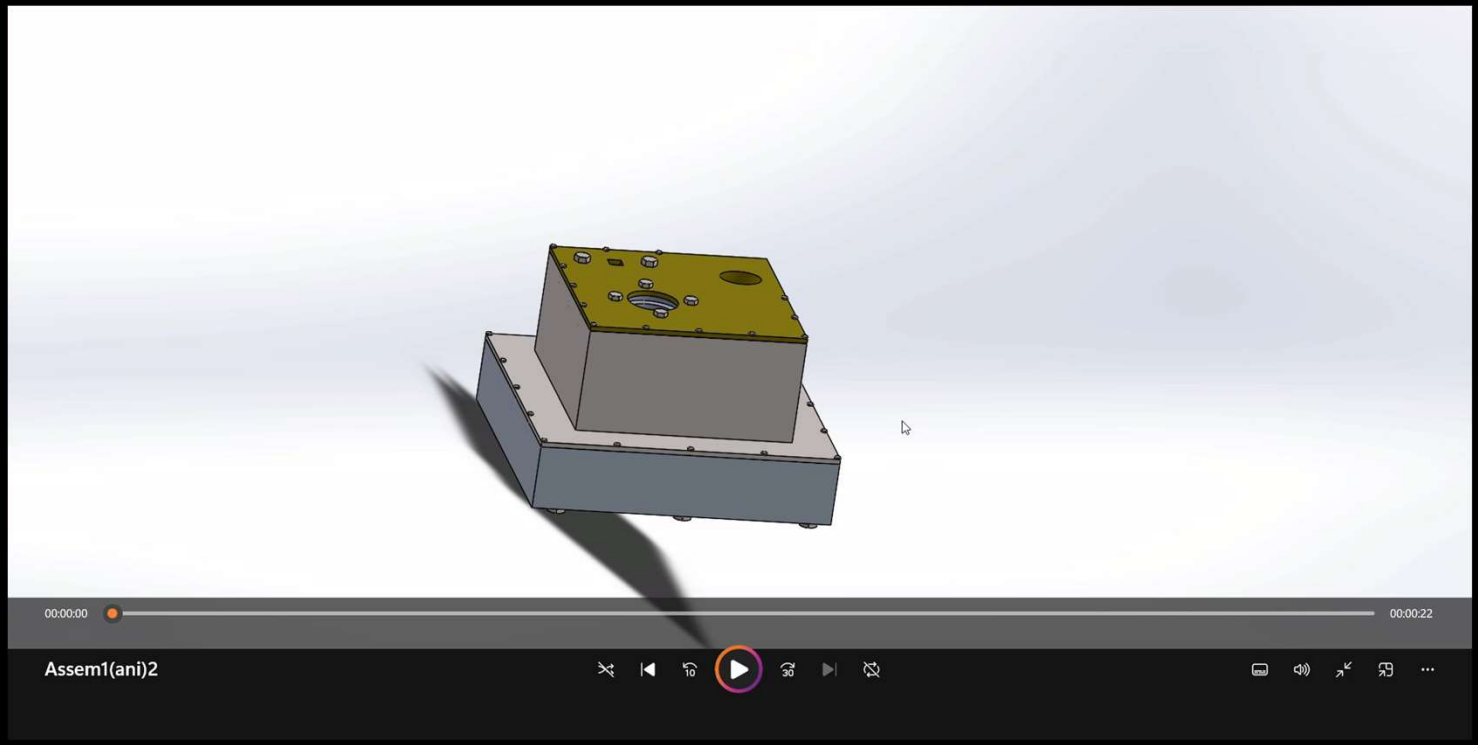
6. Internal Circularity Measurement : Internal circularity of the sensor pocket can be measured by Coordinate measuring machine.

Also for any other measurement we can use Coordinate Measuring Machine (CMM) except roughness.

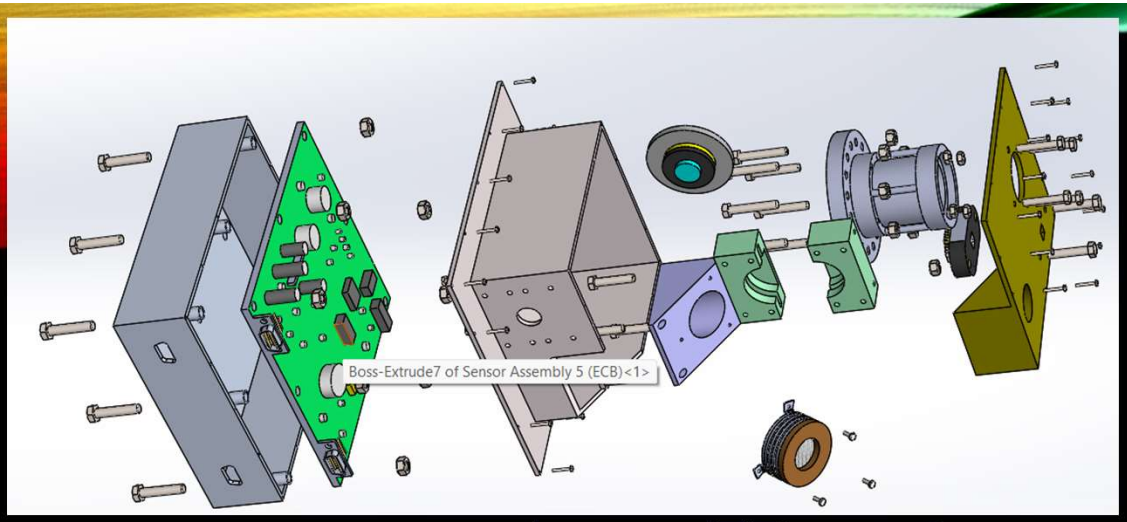


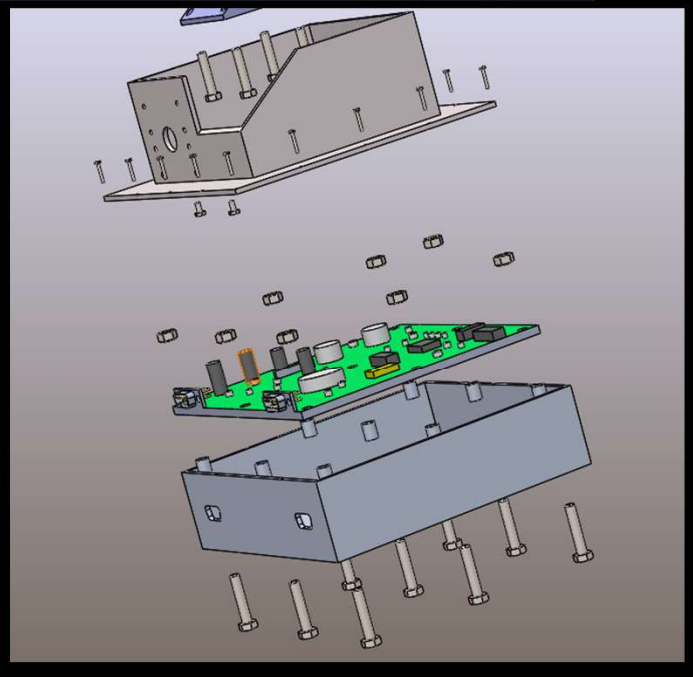
Coordinate Measuring Machine (CMM)

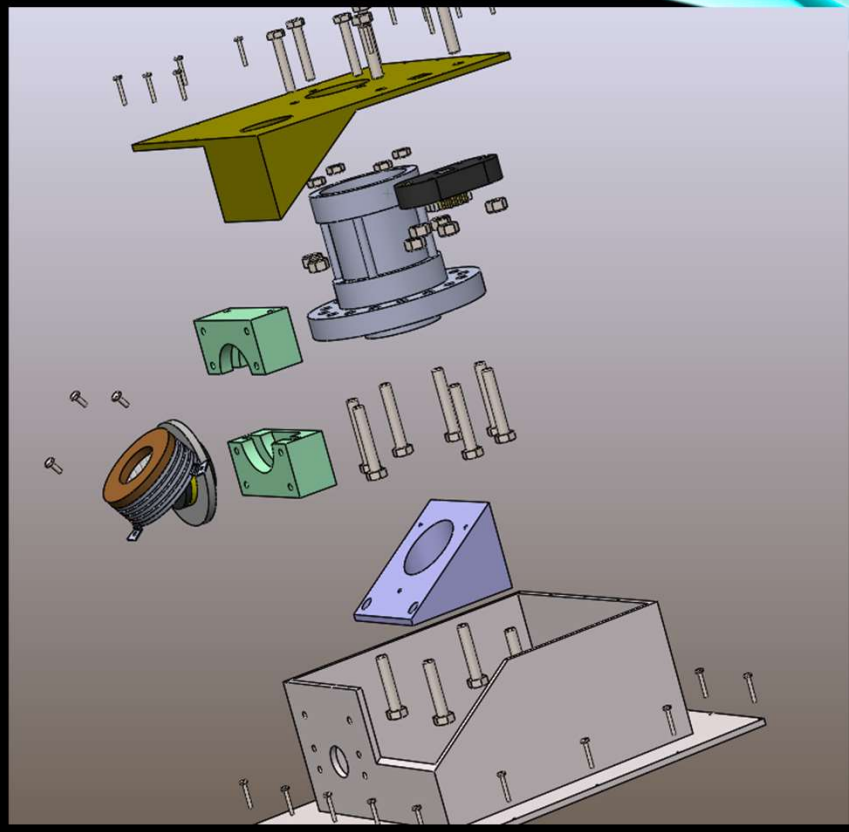
ASSEMBLY VIDEO



View 3d pdf and video


Boss-Extrude7 of Sensor Assembly 5 (ECB)<1>





Thank You