T.C.
IZMIR KATIP CELEBI UNIVERSITY FACULTY OF ENGINEERING AND ARCHITECTURE DEPARTMENT OF MECHATRONICS ENGINEERING

Stress – Strain Test Machine

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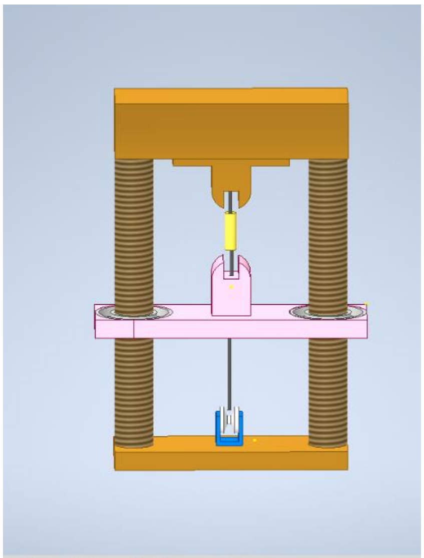
A. Introduction

The project aims to design a micro stress-strain test machine. It will test tensile and elongation changes. These changes will be transformed into stress and strain. It must be observed in the graph of the stress-strain simultaneously. To do that must be known the strength of the materials subject very well. This is necessary to properly develop the design elements of any machine or structure. In this test, a specimen is placed in a testing machine that is formed by two jaws, one plate that is fixed and one adjustable plate. The specimen in the project is 2 types of pasta. It will be tested raw and cooked pasta types separately. So, to pull pasta properly must be chosen the correct materials. When it is pulled pasta, it will create a stress maximum in the middle of the pasta. Then, it will be pulled to the fracture point. The tensile test is used to determine the physical properties of materials, stress and their elastic constants are very important. The position displacement of the adjustable jaw will help to determine the strain. These are the main idea of the project. So, it must be done in the best proper and efficient way.

B. Final Idea Process of Mechanism

Our design includes 3 aluminium plates, the bottom and top aluminium plates are fixed middle aluminium plate can move up and down along two shafts these shafts are also connected to fixed aluminium plates. The middle aluminium plate is connected to the shafts with screw shaft so it can move precisely. At first, we were planning to make the support shafts threaded, but then we decided not to use them because the threaded arms did not move as we wanted. Also, in the support shafts we used a linear ball bushing to prevent it from rotating around, we used a 12-volt DC motor to move the middle aluminium plate, the motor is attached to the motor flange and flange lift shafts. With flange lift shafts motor has a height for attaching the belt pulley system to the bottom of the motor. DC motor connected to belt pulley mechanism and belt and pulley mechanism is connected to the screw shaft, so the middle aluminium plate can move. We located a load cell in the middle aluminium plate. At first, we were thinking of using a force sensor to determine the stress, then after some research, we thought it would be better to use a load cell instead of the force sensor. The load cell is a sensor or a transducer that converts a load or force acting on it into an electronic signal. Also, to determine strain, a linear potentiometer is used as a position sensor instead of a rotary potentiometer. In design, the slot is connected to the middle aluminium plate and linear potentiometer. When the middle aluminium plate is pulled down the potentiometer value will change. So, the position displacement of the middle aluminium plate will be transformed into potentiometer values. Then, these values will be transformed into millimetre values to determine the strain. To pull the pasta we use 2 different clamps mechanisms to hold the pasta, one of them for cooked pasta and the other for uncooked pasta. For, cooked pasta we designed a spring clamp. At the head of the clamp, it is placed castermid for pressing properly. For, uncooked pasta we designed a bolt clamp. We placed one of these clamps on top of the load cell and the other under the top aluminium plate. These clamps will allow us to pull the pasta. When we will pull the mechanism, there was a problem. How will we re-adjust the aluminium plates? We have to turn the motor in the reverse (clockwise) direction. So, we got help from electrical engineers. They designed an electrical box which has relays and buttons. This box lets us turn the motor in a reverse or straight direction. The electrical box is on the top of the aluminium plate. We tried to obtain the stress-strain graph by transferring the values of the load cell and linear potentiometer to the computer with Arduino.



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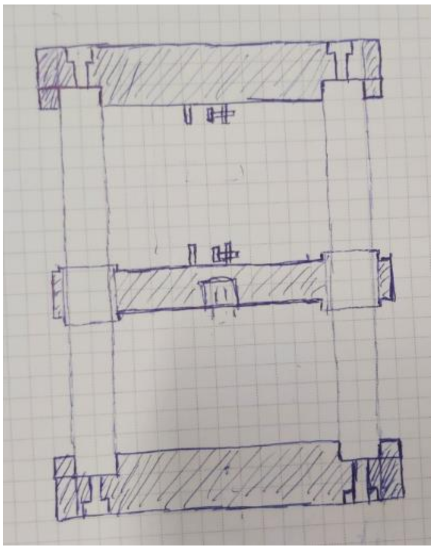
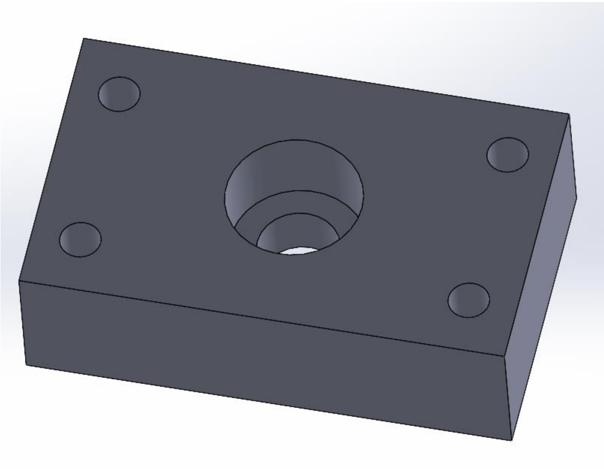
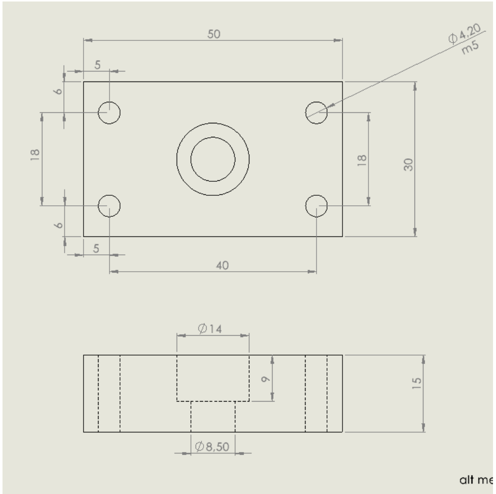


New

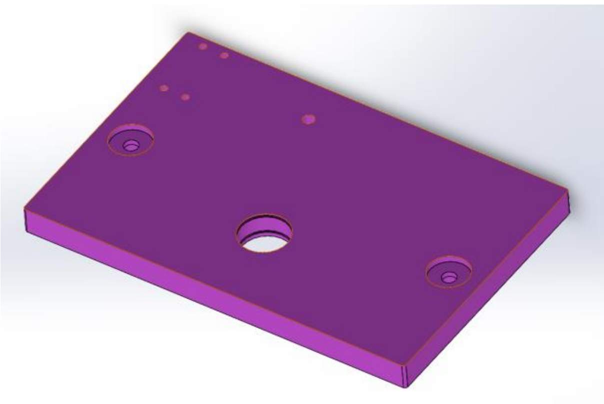
C. Manufacturing of the Materials

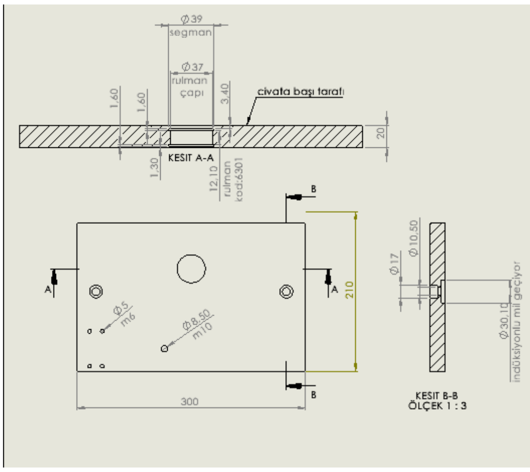
1. 3D Drawings



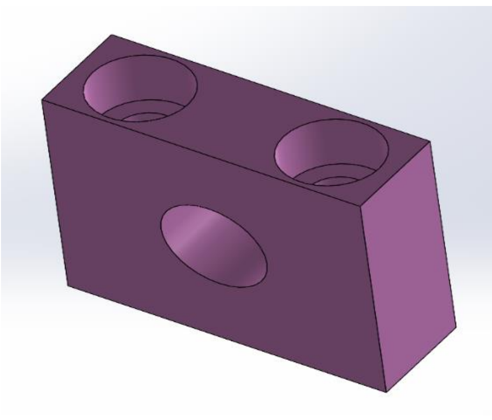


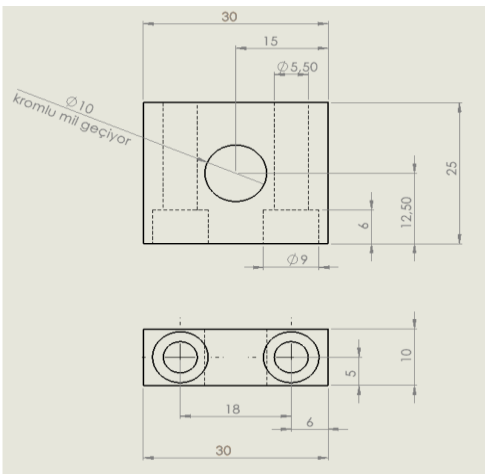
Lower Clamp Base **Technical Drawing**



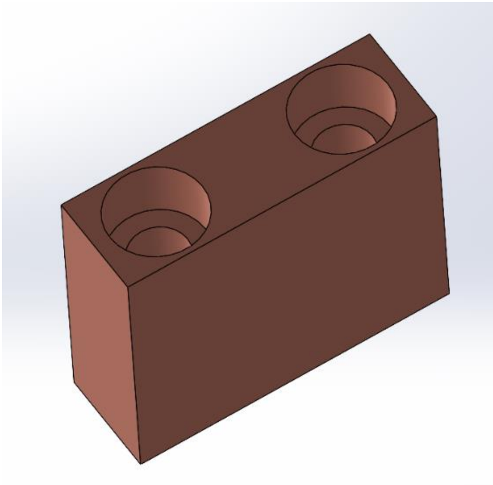


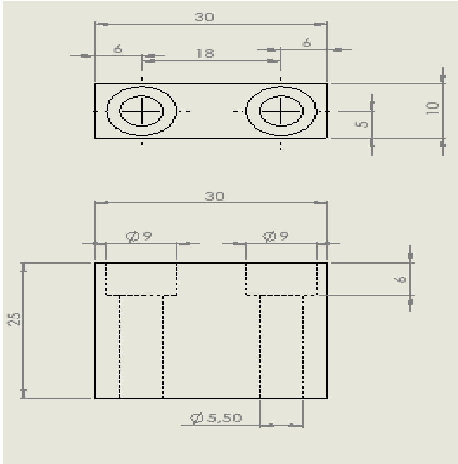
Bottom Plate **Technical Drawing**



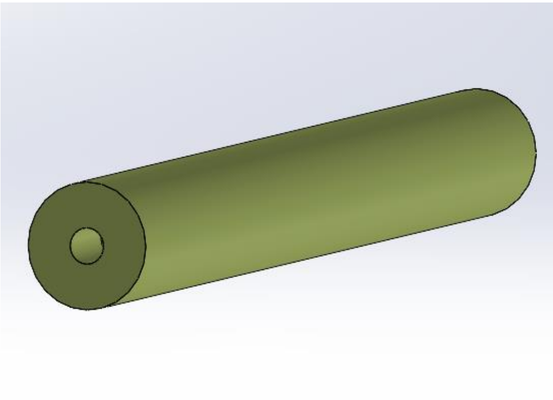


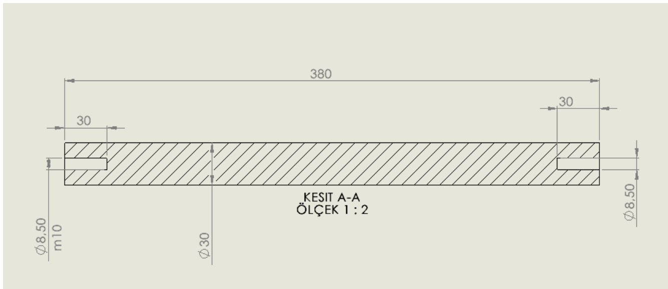
Clamp Mechanism With Hole **Technical Drawing**



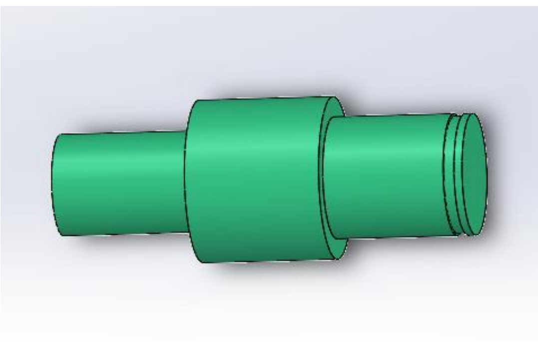


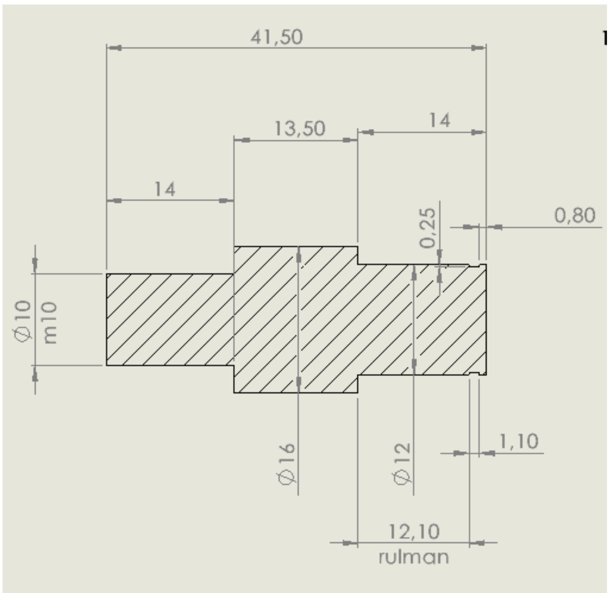
Clamp Mechanism With No Hole **Technical Drawing**



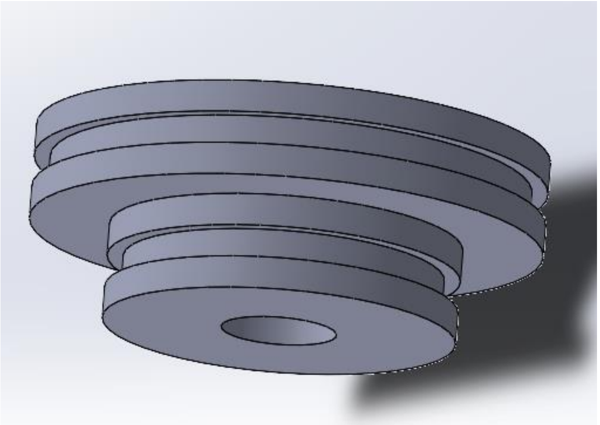


Support Shaft **Technical Drawing**

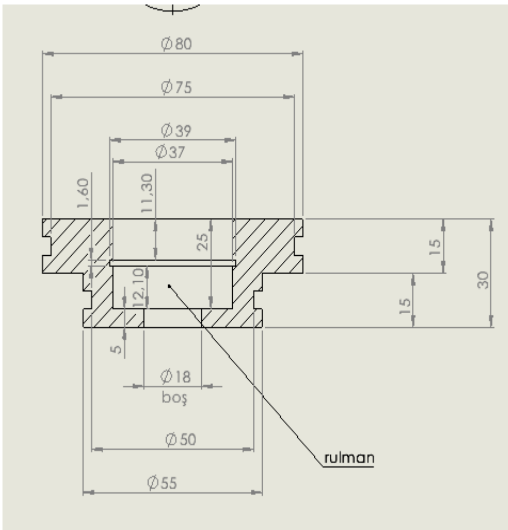




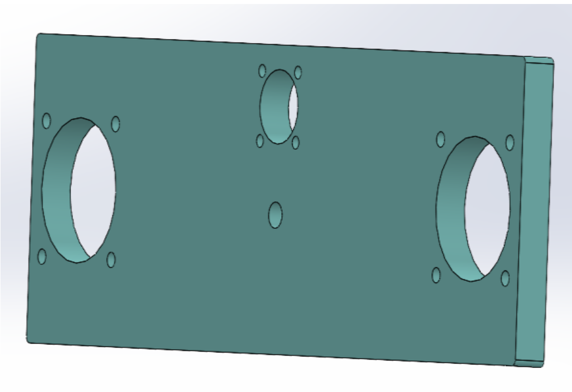
Middle Pulley Shaft **Technical Drawing**



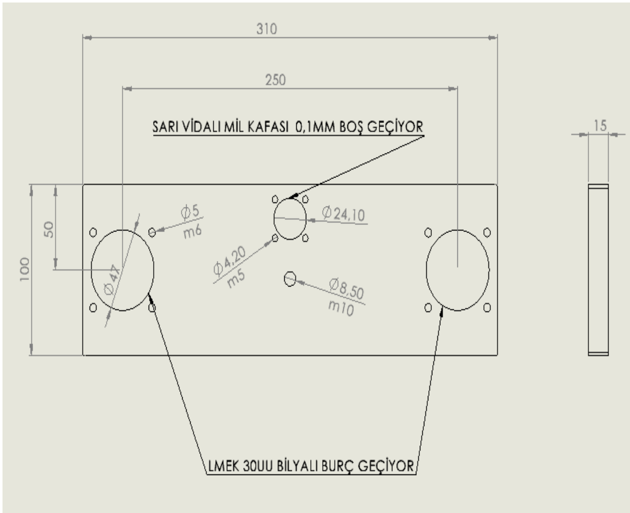
Middle Pulley



Technical Drawing



Middle Plate



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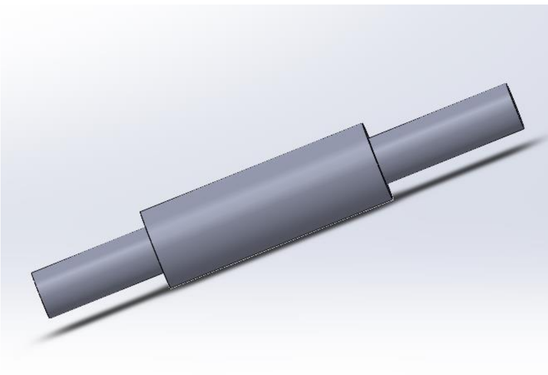
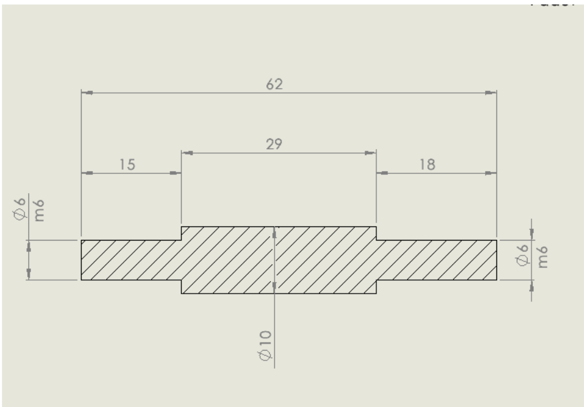
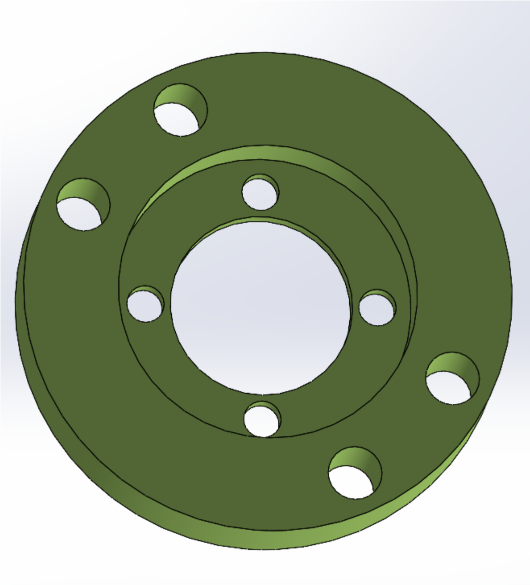
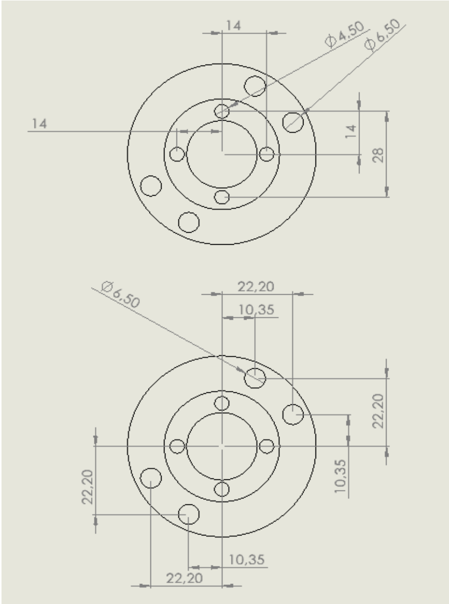


Flange-Raising Shafts

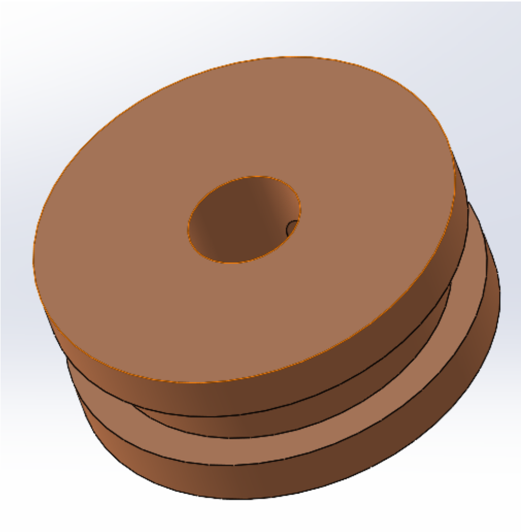


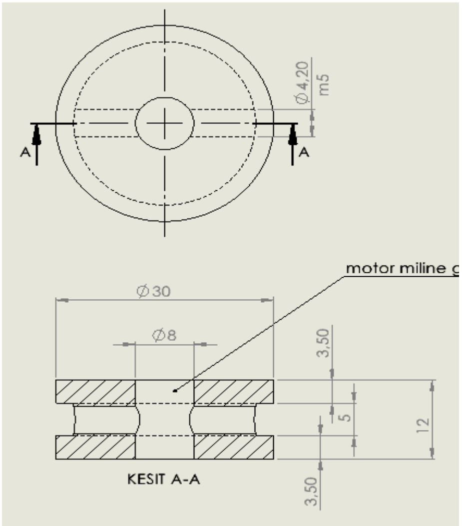
Technical Drawing



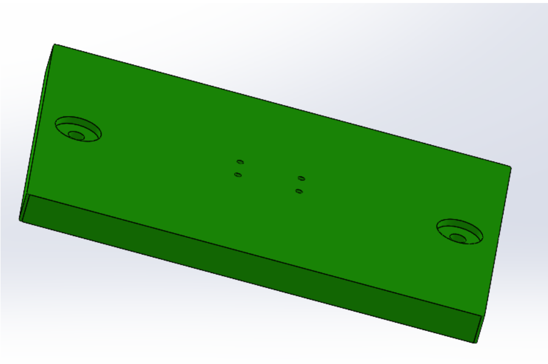


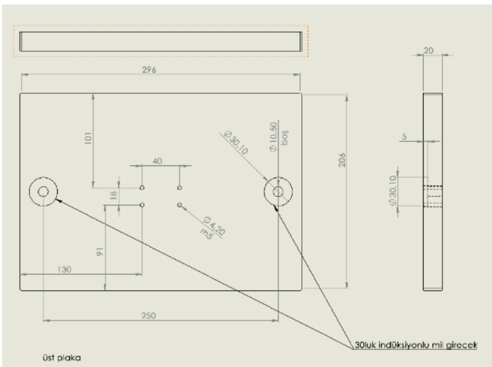
Motor Flange **Technical Drawing**



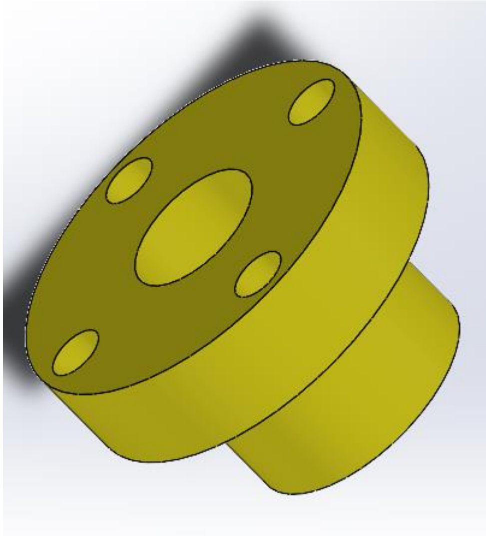


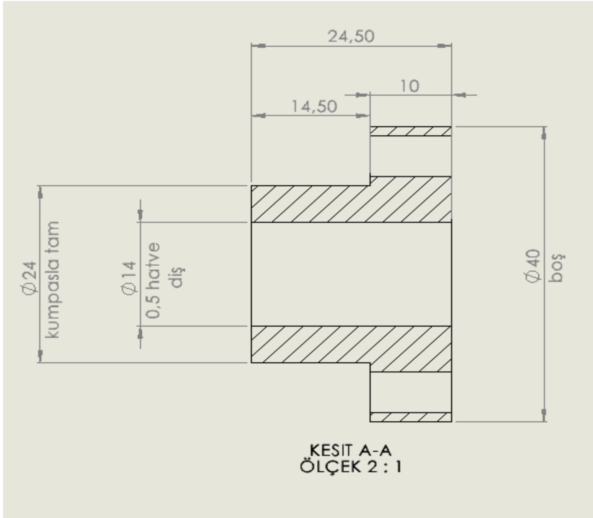
Motor Pulley **Technical Drawing**



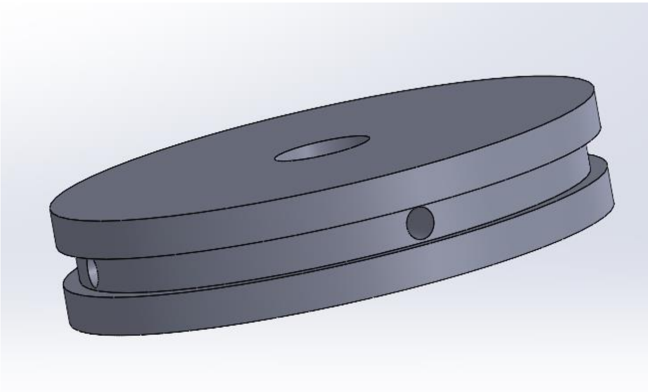


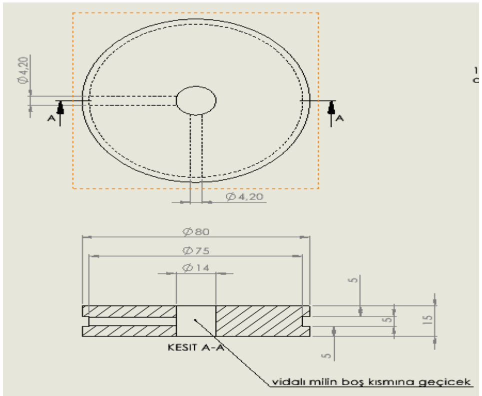
Top Plate **Technical Drawing**



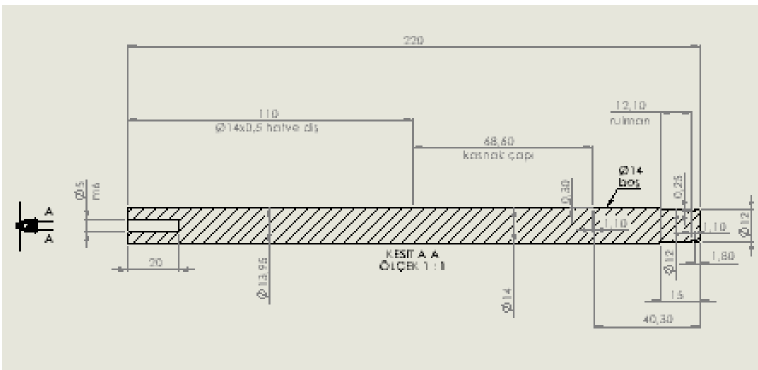


Screw Bolt **Technical Drawing**

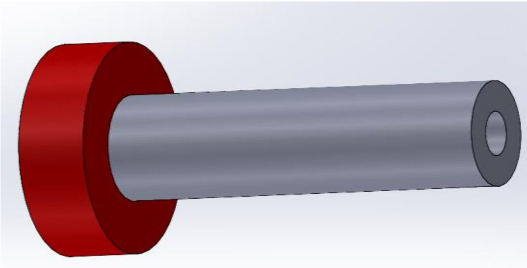




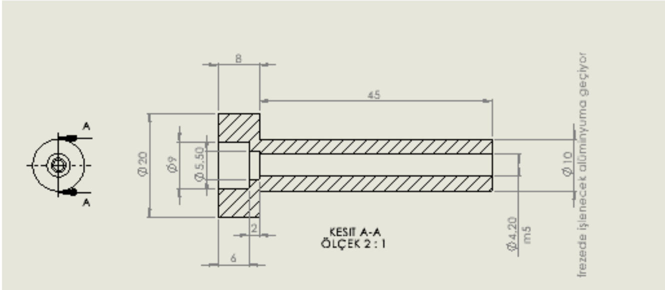
Screw Shaft Pulley **Technical Drawing**



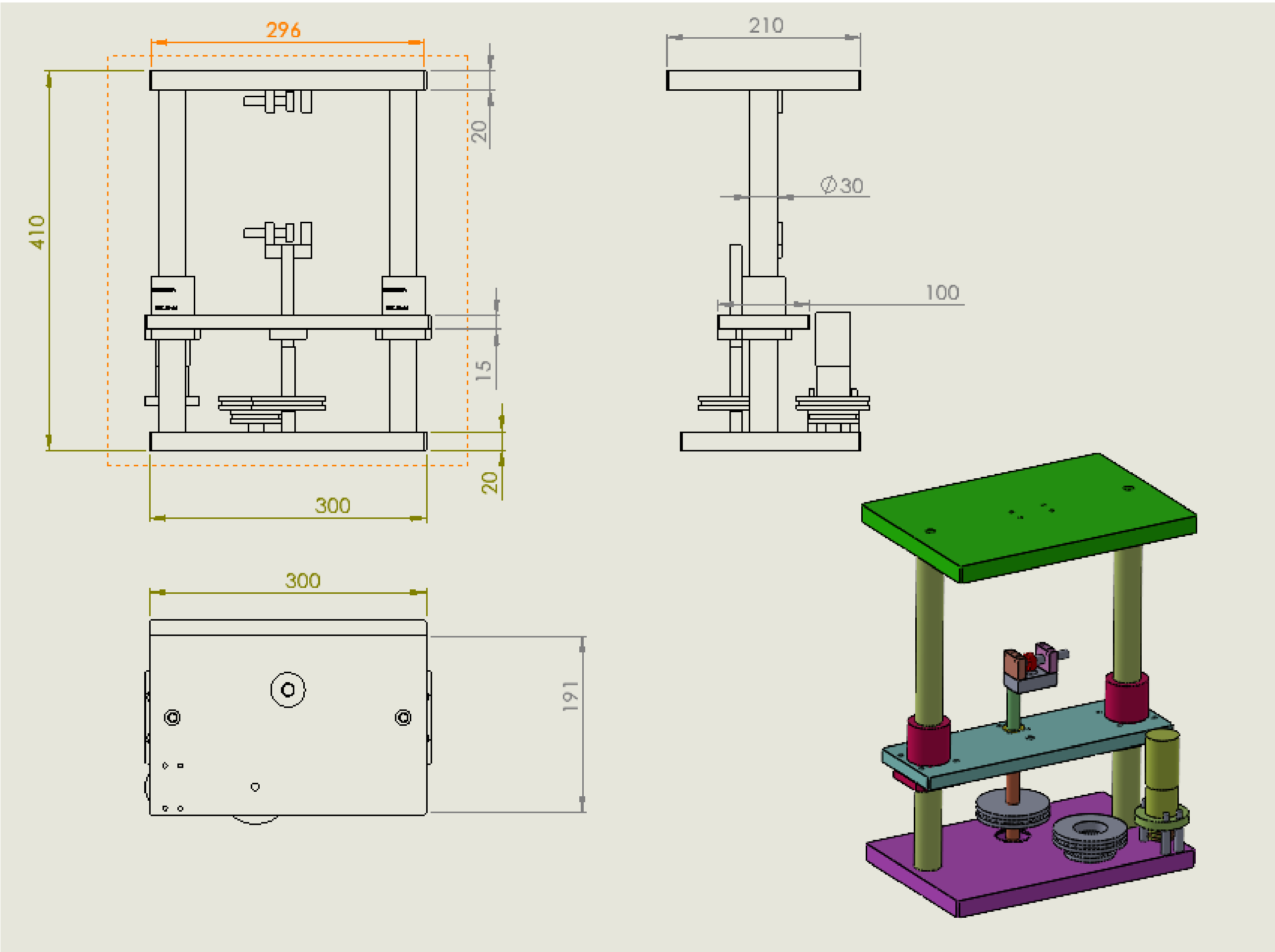
Screw Shaft **Technical Drawing**



Spring Clamp Mechanism



Technical Drawing



Assembly

2. Main Materials

Planetary Geared DC Motor 12V 36mm

S – Type Load Cell 50 Kg Capacity

Linear Potentiometer

Power Supply

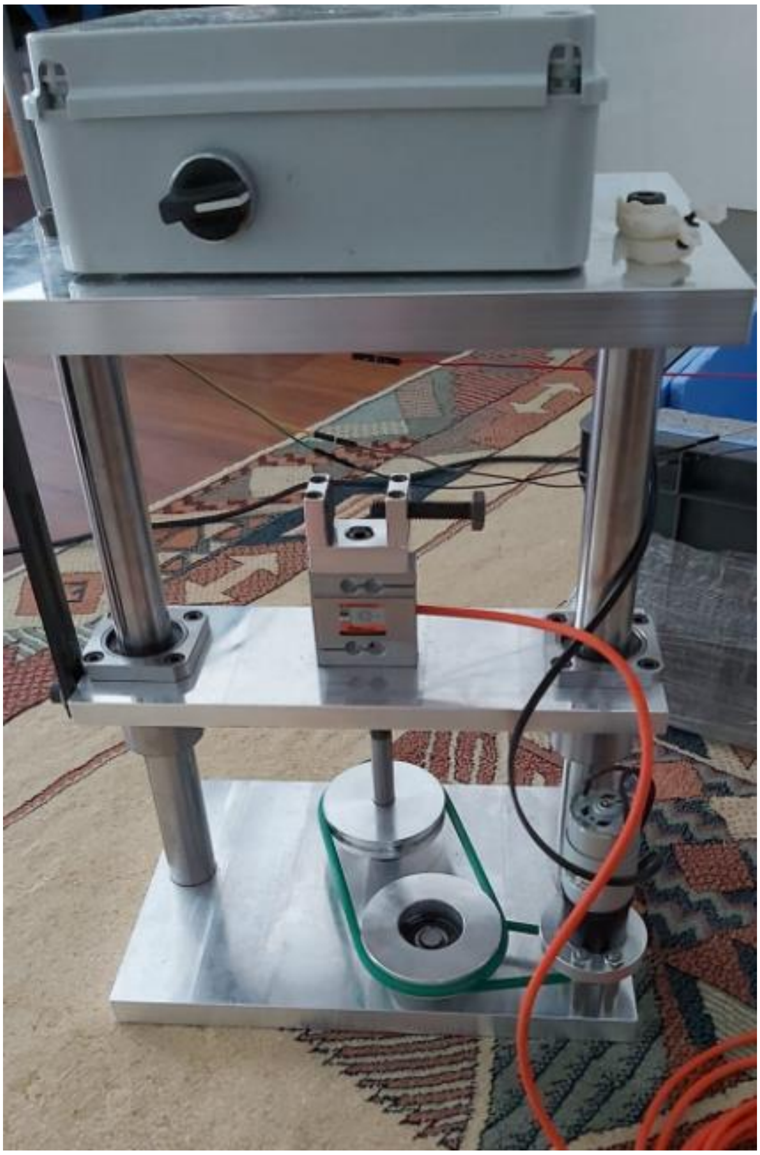
Electrical Box

It helps us to switch cable direction. It has relay and button. So, this gives us shut down the motor, turn into reverse and straight direction

Arduino

D. Manufactruing of the Design

3. Assembly of the Design



In the main structure of the design, we used 3 aluminium plates and we assembled the aluminium plates with 2 shafts. According to 3D drawings of the mechanism, we used hex headed bolts to connect the pieces of structure. We mounted the linear ball bushings between the middle aluminium plate and the support shafts. Linear ball bushings keep the structure stable. We designed a belt pulley system for the bottom aluminium plate to reduce the rpm of the DC motor. We connected the belt pullet system with o-rings. To put these pulleys below the motor, we raised the motor from the ground using a flange. After the pulley was under the motor, we mounted the middle pulley. We put a bearing inside the middle pulley and we put an inner ring so that the bearing does not move up and down. Then we mounted the pulley and the bearings under the ball screw. We fixed the screw shaft using a screw nut between the bottom and middle aluminium plates. We placed the load cell on the middle aluminium plate. We mounted the clamps on the top and bottom aluminium plates. Also, we placed the linear potentiometer at the slot next to the middle aluminium plate. We placed the electric box, which determines the direction of movement of the motor, at the top. The cable connection of the mechanism is as follows; It goes from the power source to the box, from the electrical box to the motor.

4. Software of the Design

In this structure, we preferred to use Arduino Uno for easier programming for the software.

We have created the code below to see the instantaneous values (increase and decrease) of the linear potentiometer we used in our construction.

sketch_may19a | Arduino 1.8.19

Dosya Düzenle Taslak Araçlar Yardım

sketch_may19a

```
#define potpin A1
int deger = 0;
void setup() {
  Serial.begin(9600);
  Serial.println("Pot Deger Okuma");
}
void loop() {
  deger = analogRead(potpin);
  float mm = (70.00 / 1024.00) * deger;
  Serial.println(mm);
}
```

Firstly, in order to get the value from our linear potentiometer, we defined the A1 pin of our Arduino to our software. Our value will start from zero and when the linear potentiometer in our structure goes up, the value will increase, and when it goes down, it will approach zero.

We started communication over 9600 baud rate. It shows the maximum distance of our 1024 potentiometer.

```
COM4

4.03
4.03
4.10
4.03
4.03
4.10
4.03
4.10
4.03
4.10
4.03
4.10
4.10
4.03
4.03
4.1
☑ Otomatik Kaydırma ☐ Zaman damgasını göster
```

```
COM4

69.93
69.93
69.93
69.93
69.93
69.93
69.93
69.93
69.93
69.93
69.93
69.93
69.93
69.93
69.93
☑ Otomatik Kaydırma ☐ Zaman damgasını göster
```

The software of the load sensor we use in our structure is as follows.

sketch_may24a | Arduino 1.8.19

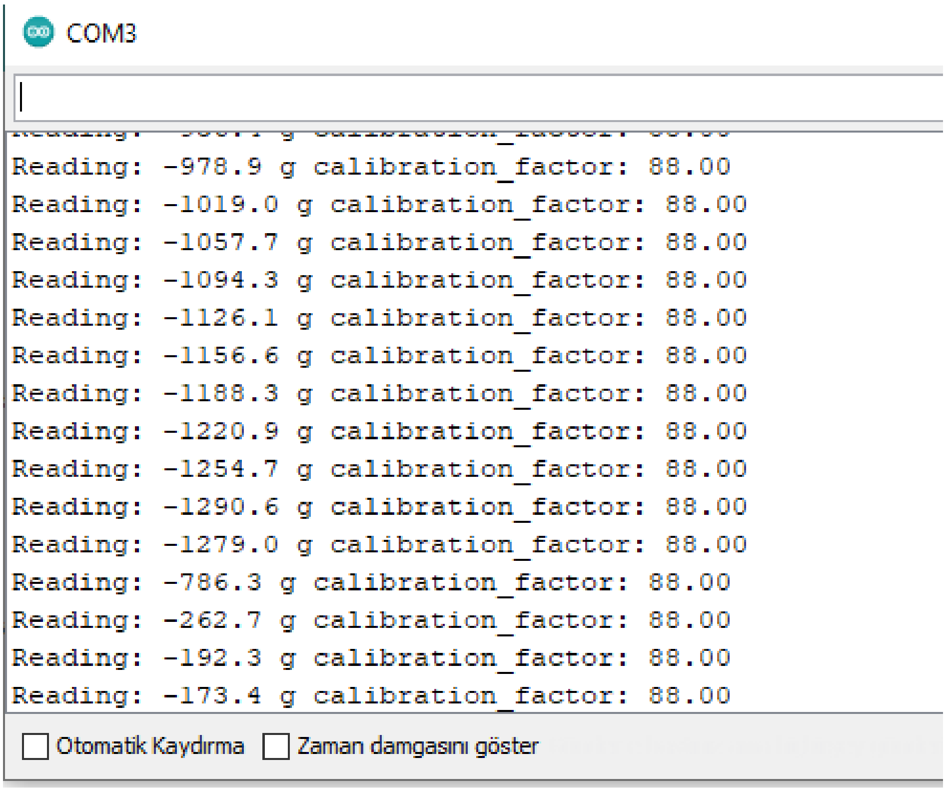
Dosya Düzenle Taslak Araçlar Yardım

sketch_may24a

```
#include "HX711.h"
#define LOADCELL_DOUT_PIN  3
#define LOADCELL_SCK_PIN  2

HX711 scale;

float calibration_factor = +88; //1 kg = 7,26778090

void setup() {
  Serial.begin(9600);
  Serial.println("HX711 calibration sketch");
  Serial.println("Remove all weight from scale");
  Serial.println("After readings begin, place known weight on scale");
  Serial.println("Press + or a to increase calibration factor");
  Serial.println("Press - or z to decrease calibration factor");

  scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
  scale.set_scale();
  scale.tare(); //Reset the scale to 0

  long zero_factor = scale.read_average(); //Get a baseline reading
  Serial.print("Zero factor: "); //This can be used to remove the need to tare the scale. Useful in permanent scale projects.
  Serial.println(zero_factor);
}

void loop() {

  scale.set_scale(calibration_factor); //Adjust to this calibration factor

  Serial.print("Reading: ");
  Serial.print(scale.get_units(), 1);
  Serial.print(" g"); //Change this to kg and re-adjust the calibration factor if you follow SI units like a sane person
  Serial.print(" calibration_factor: ");
  Serial.print(calibration_factor);
  Serial.println();

  if(Serial.available())
  {
    char temp = Serial.read();
    if(temp == '+' || temp == 'a')
      calibration_factor += 10;
    else if(temp == '-' || temp == 'z')
      calibration_factor -= 10;
```

The calibration process is performed to ensure that the load cell products that measure weight by pressure give accurate results.

We defined the weight of our load sensor in gram.

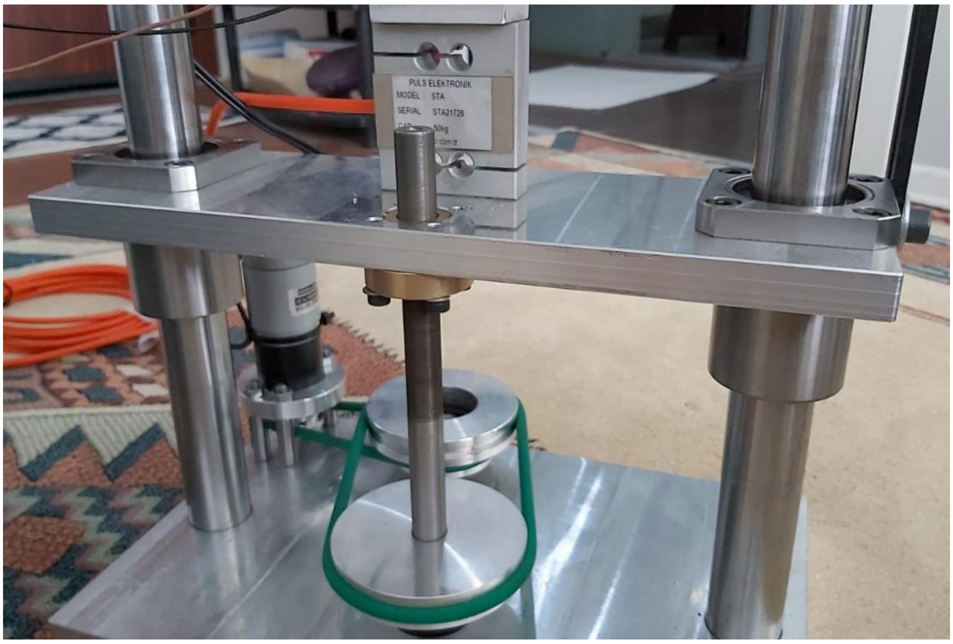


We created the code and we observe the value at which our uncooked pasta is broken.

Since the weight of the pasta we pulled was very light, our load sensor could not calculate this force and we could not create our stress-strain graph as we planned.

E. How the Design Works?

We power the dc motor with a 12V power supply to ensure movement. The DC motor is also a rotating shaft. There is a reduction system under the engine. The reduction system reduces the RPM of the engine in the mechanism and increases its torque. This reduction system consists of pulleys. The pulleys are connected by o-rings. To install this reduction system, we need to increase the engine's height level. For us to provide this, we have designed a flange that we can connect to the engine. He helped us to raise it to such a height that we could attach a pulley to the bottom of the engine thanks to the flange-raising shafts. When the motor rotates, the pulley to which the ball screw is connected rotates the ball screw. This machined screw shaft with a screw pitch of 0.5 mm also provided the ability to move the middle aluminium plate in the y plane by turning the motor upside down or straight. The reverse or straight rotation of the motor is also provided by the electric box. Thanks to the relays and the button, the motor inside the electrical box move in reverse or straight. When the engine rotates in the direction counterclockwise, our adjustable aluminium plate goes down. and when the engine rotates in the direction clockwise, our middle aluminium plate moves upwards. thanks to the screw nut around the ball screw, our aluminium plate does not move to the right or left, it remains stationary. we have two centring shafts holding our three aluminium plates. thanks to the linear ball bushings surrounding the centring shafts on the middle pulley, our middle aluminium plate slides comfortably and the aluminium plate does not move left and right thanks to the bearings inside. Thanks to the clamps on the middle and top aluminium plates, we also pull out the pasta. We measure the stress with an S-type load cell that we have defined on the Arduino. we fixed the linear potentiometer with the slot, which we also fixed on the middle aluminium plate. as the middle aluminium plate moves up and down, our linear potentiometer moves in the same way. the bar of the potentiometer is moving up because the potentiometer is moving down when pulling the pasta. thus, we calculate the strain.



F. Bill of Materials (BOM)

Material	Quantity	Price
Planetary Geared DC Motor	1	295 TL
S – Type Load Cell	1	1400 TL
Linear Potentiometer	1	55 TL
Screw Shaft	1	Free
Linear Ball Bushing	2	200 TL
Support Shaft	2	Free
Aluminium Plate	3	Free
Pulley	3	Free
Chrome Shaft	2	Free
Spring	2	Free
Bolt	2	Free
Screw Nut	1	Free
Nut	4	Free
Hex Headed Bolt	28	Free
O-Ring	2	Free
Bearing	2	Free
Power Supply	1	Free
Hot Silicone Gun	1	50 TL
Sandpaper	1	10 TL
Electrical Box	1	Free
Inner Ring	8	Free
Double-Sided Tape	1	20 TL
HX711 Amplifier	1	25 TL
Castermid	2	Free
	Total	**2055 TL**

G. Conclusion

- The purpose of designing this project is to instantly observe the stress-strain graphs of objects with low durability. The object we use for this project is pasta. First, we placed the uncooked pasta and then the cooked pasta in our mechanism and observed the stress-strain graphs of both of them instantly. As expected, the stress-strain graph of the cooked pasta was interrupted as it continued parabolic for a certain period and then broke. The stress-strain graph of uncooked pasta, on the other hand, was interrupted because it continued linearly for less time and then broke. In this experiment, after applying some processes to the same substance. But, we couldn't we observed these definitions. That was a challenging part for us.