Claw Machine

ENME401 Strength of Materials Project

Team 36: **SPARKIH**

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RECAP

Ultimate stresses throughout the whole document:

- $\sigma_{ult,\ PLA} = 33$ MPa
- $\tau_{ult,\ PLA} = 37.5$ MPa
- $\sigma_{ult\ ,\ steel} = 420$ MPa
- $\tau_{ult,\ Steel} = 280$ MPa
- $\sigma_{ult,\ Cardboard} = 1.48$ MPa
- Factor of safety n = 2

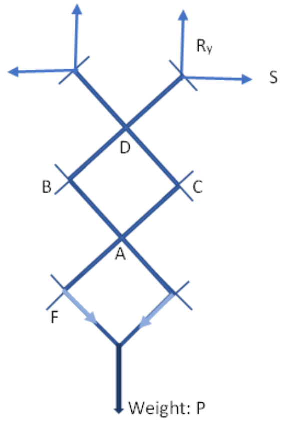
❖ Dimensions:

- Weight of the load: P = 5 N (m = ~500g)
- Thickness of links: t = 5 mm
- Width of links: w = 10 mm
- diameter hole: d = 2 mm
- Angle of the fingers with the horizontal: $\theta = 40°$
- S = 46.65 N (Force coming from the syringe at angle: $\theta = 15°$ please refer to p.15-16 first report for its calculation)
- Weight of the roof: P = 20 N
- Width of the column 20 mm and its thickness 10 mm.

❖ Analysis:

- Gripper:
  - Normal Stress: σ = F/A = $\frac{\frac{5}{3}}{5*(10-2)} = 0.04167\ MPa$
  - Shear Stress: $\tau_{finger} = 0.0333$ MPa; $\tau_{pin} = 0.6907$ MPa
  - Bearing Stress: $\sigma_b = 0.217$ MPa

- Z-fork:



  - Normal Stress (Link BDR): $\sigma = \frac{45.71}{5*(10-2)} = 1.14\ MPa$
  - Shear Stress: $\tau_{pin\ D}$ = 23.76 MPa
  - Bearing Stress: $\sigma_{b,\ D}$ = 7.464 MPa
- Column:
  - Normal Stress: $\sigma = \frac{-\frac{P}{4}}{w*t}\ \frac{-5}{20*10} = -0.025\ MPa$

❖ Design:

- Grip and Z-Fork:

The maximum load that will satisfy a factor of safety of 2 in the grip and the z-fork is:

P = 11.05 N obtained from bearing stress at pin D (m = 1.127 Kg)

- Column:

$\sigma = \frac{-\frac{P}{4}}{20*10} = -0.74\ MPa$ (Compression)

$\rightarrow$ P = 592 N

Therefore, the columns can withstand up to 60.34 Kg as weight of the roof including the components.

SERVO MOTOR

We will be using a rack and pinion mechanism.[1]

$$T = r \times F$$

T: Torque of the servo motor chosen in this case 3.2 kg.cm = 313.6 N.mm

F: Force needed to move the structure; as per calculated in the first report (p.15-16) F = 46.65 N, by consequence the force needed to push the syringe assuming the same syringe size on both ends is also 46.65 N (constant pressure)

r: Radius of the gear (pinion) needed

⇨ $r = \frac{T}{F} = \frac{313.6}{46.65} \approx 6.722\ mm$ (Rounded down, maximum radius acceptable)

[1] https://www.thingiverse.com/thing:465349

As this value is too small, we will choose a higher torque.

T_{new} = 10 kg.cm = 981 N.mm;

- ⇨ $r = \frac{T}{F} = \frac{981}{46.65} \approx 21.028\, mm$ (Rounded down, maximum radius acceptable)

Therefore, we will use a gear with radius 20 mm.

- ❖ Speed of the servo: 0.12 sec /60 degree
- ❖ The maximum angle of the servo is 180°

$\theta_{max} = 180° = \pi\, rad$

- ❖ Time needed is 0.12*3 = 0.36 sec
- ⇨ $\omega = \frac{\frac{\pi}{3}}{0.12} \approx 8.727\, rad/s$
- ⇨ $Length\ of\ the\ arc = r\theta = 20 \times \pi \approx 62.83\, mm$ which is also Δl of the syringe (please refer to p.24 for further details about the choice of syringe)
- ⇨ Velocity of the moving rack: $v = \omega \times r = 8.727 \times 20 = 174.53\, mm/s$

(A photo of the motor to be used can be found at p.23)

TORSION

To calculate the maximum shear and torsion, we will assume that a solid steel shaft is connected to the motor and at its end a gear is connected:

- $\tau_{\text{ult, steel}}$ = 280 MPa
- safety factor = 2
- τ_{all} = 140 MPa
- $\tau = \frac{Tc}{j} = \frac{Tc}{\frac{\pi}{2} * c^4} = \frac{2T}{\pi * c^3}$ => $140 = \frac{981*2}{\pi * c^3}$ => c = 1.647 mm (rounded up)

Knowing that:

- L_{shaft} = 10 mm
- c_{shaft} = 1 .647mm
- G_{steel} = 79.3 GPa

⇨ $J = \frac{\pi}{2} * c^4 = 11.56\ mm^4$

As we don't want the angle of twist to exceed 1 degree, the maximum length of the shaft needed is:

⇨ $\varphi_{\text{shaft}} = \frac{TL}{GJ} => 1\ \text{deg} = 0.01745\ rad = \frac{981*L}{79.3*10^3*11.56}$

$$L \approx 16.31\ mm$$

BENDING

❖ Analysis:

Assuming:

- The weight of the roof is 20N
- Its width is 500 mm
- Its length is 500 mm
- The width of the column is 20 mm
- its thickness is 20 mm
- its length is 600 mm
- $E_{cardboard} = 0.93$ GPa[2]

The max bending will happen when the weight is at one of the corners A (not centred). We will study the bending moment on the opposite corner B at its extrema point P.

The diagonal of the column is $20\sqrt{2} \approx 28.28\ mm$

The diagonal length is $500\sqrt{2} \approx 707.1\ mm$

Taking the origin of our axis at the centroid of the column C_B.

The distance from C_A to C_B is $d = 500\sqrt{2} - 20\sqrt{2} \approx 678.82\ mm$

The distance from P to C_B is $y = 10\sqrt{2} \approx 14.14\ mm$

Reducing this force into a Force-Couple System at the centroid of the column:

- $F_B = 20$ N
- $M_B = r_{A/B} \times F_A = 678.82 * 20 = 13576.45\ N.mm = 13.576\ N.m$

- Moment of Inertia of the column is:

$$I = \frac{1}{12}bh^3 = \frac{20\sqrt{2}*(20\sqrt{2})^3}{12} = \frac{160000}{3} \approx 53333.33\ mm^4$$

[2] Average value from Rigid material properties | Download Table (researchgate.net)

$$\sigma = \frac{F}{A} + \frac{My}{I} = \frac{20}{20 * 20} + \frac{13576 * 14.14}{\frac{160000}{3}} = 3.65\ MPa$$

As the calculated stress surpasses the ultimate stress, we will increase the dimension to 30x30.

The diagonal of the column is $30\sqrt{2} \approx 42.43\ mm$

The diagonal length is $500\sqrt{2} \approx 707.1\ mm$

Taking the origin of our axis at the centroid C_B of the column B.

The distance from C_A to C_B is $d = 500\sqrt{2} - 30\sqrt{2} \approx 664.68\ mm$

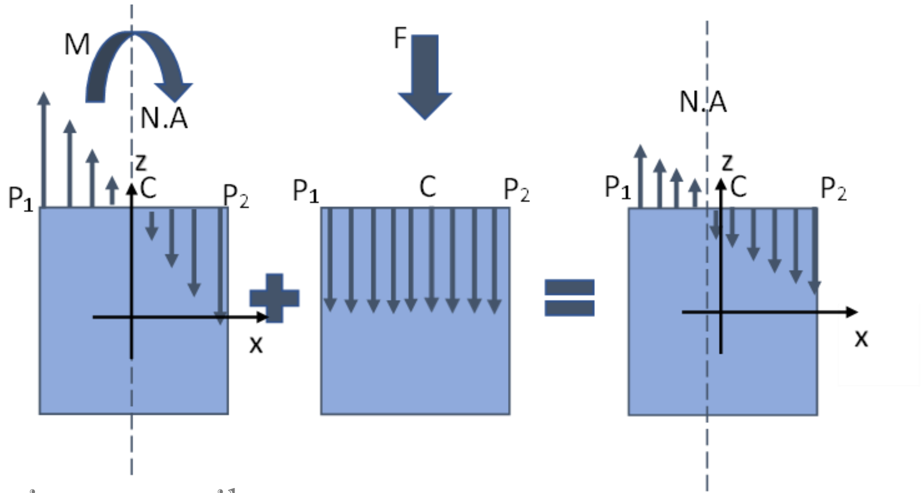
The distance from P to C_B is $y = 15\sqrt{2} \approx 21.21\ mm$

Reducing this force into a Force-Couple System at the centroid of the column:

- $F_B = 20$ N
- $M_B = r_{A/B} \times F_A = 664.68 * 20 \approx 13293.61\ N.mm \approx 13.294\ N.m$

- Moment of Inertia of the column is:

$$I = \frac{1}{12} bh^3 = \frac{30\sqrt{2} * (30\sqrt{2})^3}{12} = 270000\ mm^4$$



- Maximum tensile stress:

$$\sigma = -\frac{F}{A} + \frac{My}{I} = -\frac{20}{30 * 30} + \frac{13294 * 21.21}{270000} \approx 1.022\ MPa$$

- Maximum compressive stress:

$$\sigma = -\frac{F}{A} - \frac{My}{I} = -\frac{20}{30 * 30} - \frac{13294 * 21.21}{270000} \approx -1.067\ MPa$$

- Radius of curvature:

$$\frac{1}{\rho} = \frac{M}{EI}$$

$$\rho = \frac{930 * 270000}{13293.61} \approx 18889\, mm \ \approx 18.9\, m$$

- Distance between section centroid and neutral axis:

$$\sigma \ = -\frac{F}{A} + \frac{My}{I} = 0$$

$$\frac{20}{30 * 30} = \frac{13294 * y}{270000}$$

$$y \approx 0.4513\, mm$$

❖ Maximum load:

- $\sigma_{\text{ult, Cardboard}} = 1.48$ MPa
- Factor of safety n = 2

➔ $\sigma_{\text{all, Cardboard}} = 0.74$ MPa

$$\sigma = -\frac{F}{A} - \frac{My}{I}$$

$$-0.74 = -\frac{F}{30 * 30} - \frac{F * 664.68 * 15\sqrt{2}}{270000}$$

$$F = 13.875\ N$$

This value is reasonable as the materials used are light and the weight of the object to be lifted will not exceed 100 g which is 0.981 N and therefore the assumption of 20 N for the maximum weight of the whole roof was redundant.

❖ Design:

- $\sigma_{ult,\ Cardboard}$ = 1.48 MPa
- Factor of safety n = 2

➔ $\sigma_{all,\ Cardboard}$ = 0.74 MPa

The diagonal of the column is $c\sqrt{2}$

The distance from C_A to C_B is $500\sqrt{2} - c\sqrt{2}$

The distance from P to C_B is $y = \frac{c\sqrt{2}}{2}$

Reducing this force into a Force-Couple System at the centroid of the column:

- F_B = 20 N
- $M_B = r_{A/B} \times F_A = \left(500\sqrt{2} - c\sqrt{2}\right) * 20 = 10000\sqrt{2} - 20c\sqrt{2}$

Moment of Inertia of the column is:

- $I = \frac{1}{12}bh^3 = \frac{\left(c\sqrt{2}\right)^4}{12} = \frac{c^4}{3}$

$$\sigma = -\frac{F}{A} - \frac{My}{I}$$

$$-0.74 = -\frac{20}{c * c} - \frac{\left(10000\sqrt{2} - 20c\sqrt{2}\right) * \frac{c\sqrt{2}}{2}}{\frac{c^4}{3}}$$

$$0.74 = \frac{20}{c^2} + \frac{3 * (10000 - 20c) * c}{c^4}$$

$$0.74 = \frac{20c + 30000 - 60c}{c^3}$$

$$0.74\ c^3 = 30000 - 40c$$

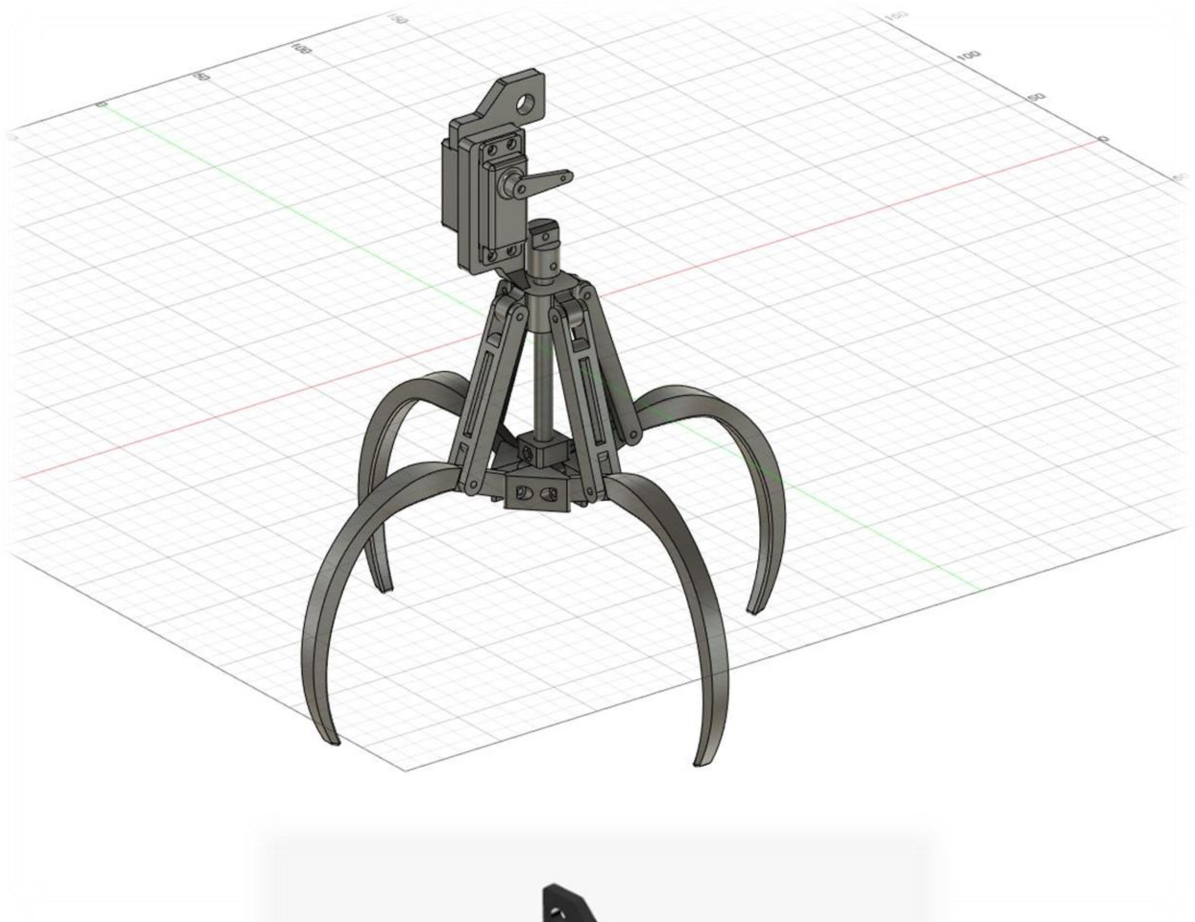
$$c \approx 33.83\ mm$$

$$(Minimum\ width\ and\ length\ of\ the\ column)$$

3D MODEL (FUSION 360)

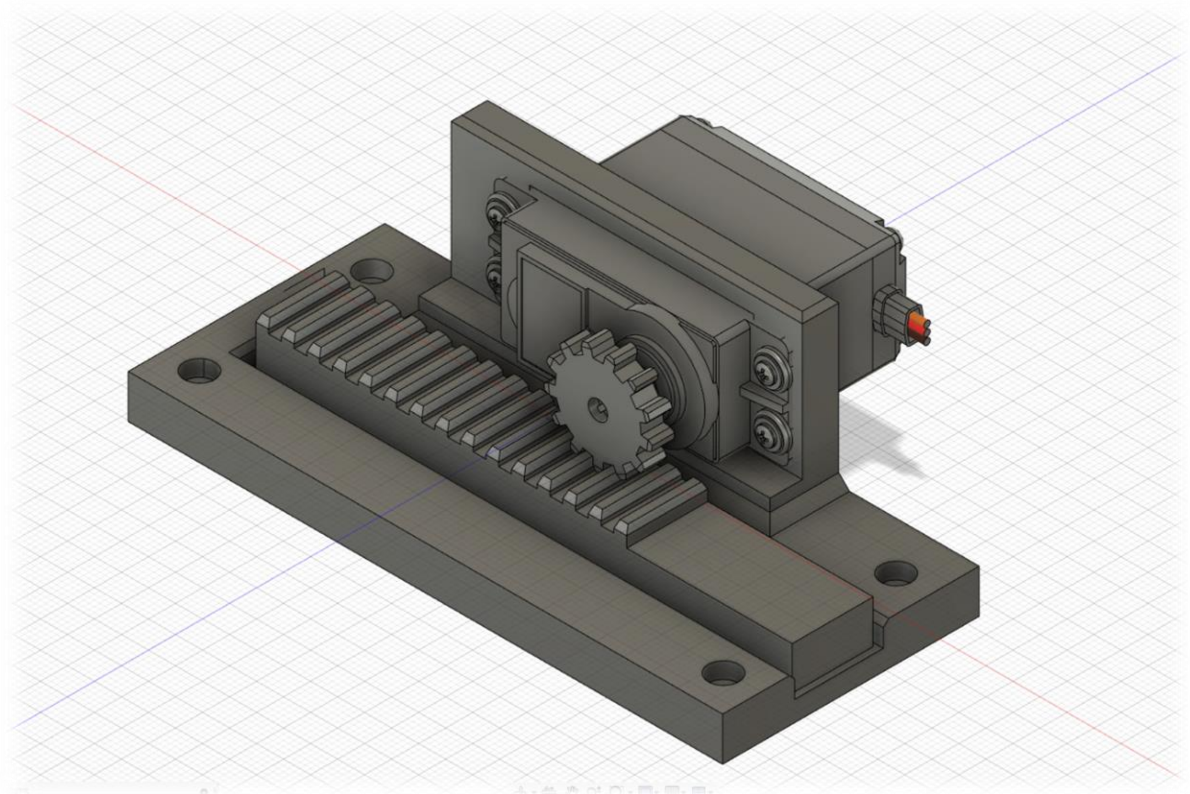
❖ Grip:

Instead of re-inventing the wheel, we chose to implement this design in our project. All credit go to [Servo actuated claw by Swhitney22 - Thingiverse]



❖ Rack and pinion mechanism:

This design was inspired from Motorized Door Lock by IamTeknik - Thingiverse, we modified and adjusted this design to suit our project along with the calculations done (mainly the servo to linear part).



CALCULATIONS

❖ Torsion:

① Torque: From servo motor the given torque = 3.2 kg.cm, calculating radius of the gear: $T = 32 \times 9.8 \times 10 = 313.6$ N.mm $\rightarrow r = \frac{T}{F} = \frac{313.6}{46.65} = 6.72$ mm

as the Force needed to move the the syringe in the Z fork = 46.65 N

→ this lead to a radius = 6.72 mm which is very small [not practical]

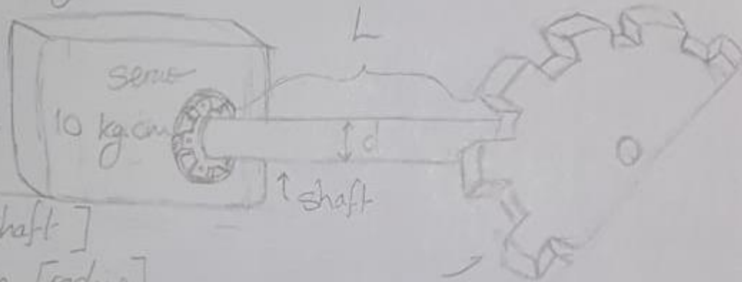
to increase the radius we need to increase the torque to maintain the required force, therefore the choosen servo will have torque = 10 kg.m

$T = 10 \times 10 \times 9.81 = 981$ N.m $\longrightarrow r = \frac{T}{F} = \frac{981}{46.65} = 21.028$ mm [max radius]

The dimension of the gear will be: $\boxed{r = 20 \text{ mm}}$

Torsion calculations [analysis]

assuming a shaft connecting the servo and the gear with dimensions equal to:



$L = 10$ mm [Solid shaft]

$d = 2$ mm $\longrightarrow C = 1$ mm [radius]

max shear: $\boxed{\tau_{max} = \frac{Tc}{J}}$, $\boxed{\text{angle of twist: } \phi = \frac{TL}{GJ}}$

calculating $J = \frac{\pi}{2} C^4 = \frac{\pi}{2} * 1^4 = 1.57$ mm^4

and for Steel: G (modulus of rigidity) [asumming the shaft material made of Steel] $G = 79.3 \times 10^3$ MPa

$\tau_{max} = \frac{981 \times 1}{1.57} = 624$ MPa $>$ [260 MPa]

Conclusion from the analysis part	→ which is much greater than the ultimate shear for the choosen material of the shaft [steel] to avoid failure: in design part we will design on the ultimate shear, so moving to the design part: →

② Design:
ultimate shear stress for steel: $\tau_{ult} = 280$ MPa $\quad n = \frac{\tau_{ult}}{\tau_{allowable}}$

using factor of safety $\boxed{n = 2}$ $\longrightarrow \tau_{allowable} = \frac{\tau_{ult}}{n} = \frac{280}{2} = 140$ MPa

$\tau_{max} = \frac{TC}{J} \longrightarrow$ calculating C: $\tau_{max} = \frac{T\cancel{C}}{\frac{\pi}{2} C^{\cancel{4}3}} \longrightarrow C = \sqrt[3]{\frac{T}{\frac{\pi}{2}\tau_{max}}}$

$\boxed{C = \sqrt[3]{\frac{980}{\frac{\pi}{2} * 140}} = 1.6456 \text{ mm}}$, $J = \frac{\pi}{2} * C^4 = 11.53 \text{ mm}^4$

accordingly, $\phi = \frac{TL}{GJ} = \frac{981 * 10}{79.3 \times 10^3 \times 11.53} = 0.017$ rad

$\boxed{\text{angle of twist} = 0.017 \text{ rad} = 0.6147 \text{ deg}}$

$\boxed{\tau_{max} = 140 \text{ MPa}}$

Designing for the length of the shaft:

assume that the angle of twist = 1 degrees $\longrightarrow$ 0.01745 rad

$\phi = \frac{TL}{GJ} \longrightarrow L = \frac{\phi G J}{T} = \frac{0.01745 \times 79.3 \times 10^3 \times 11.56}{981} = 16.31$ mm

$\boxed{\text{then the required length} = 16.31 \text{ mm}}$

$\boxed{\text{which is the max length}}$

❖ Bending

① **Bending analysis**

Δ refere in the coord document where: $A \rightarrow X$, $B \rightarrow O$

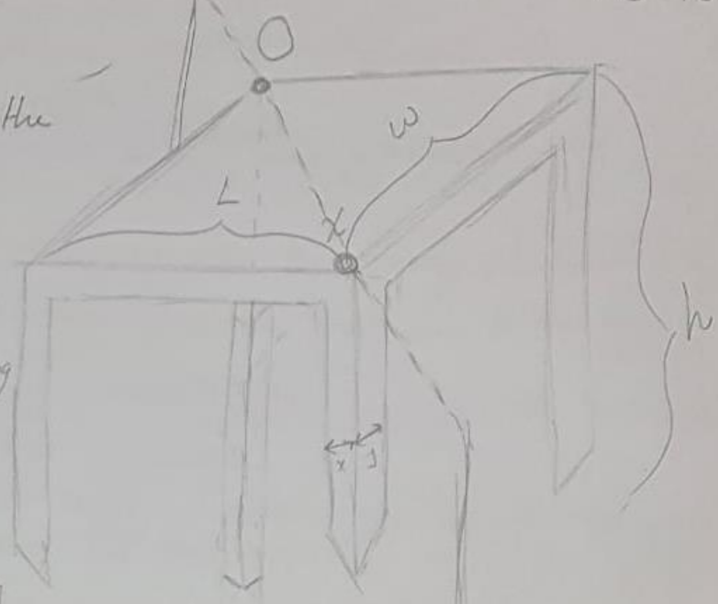
a

assuming the dimentions of the structure to be: $\boxed{L = 500m}$ $\boxed{W = 500\ mm}$, $\boxed{h = 600\ mm}$

assuming the weight @ position X and we will calculate the bending at position O [it is the max distance between the load and any point on the column so it will lead to the max bending stress]

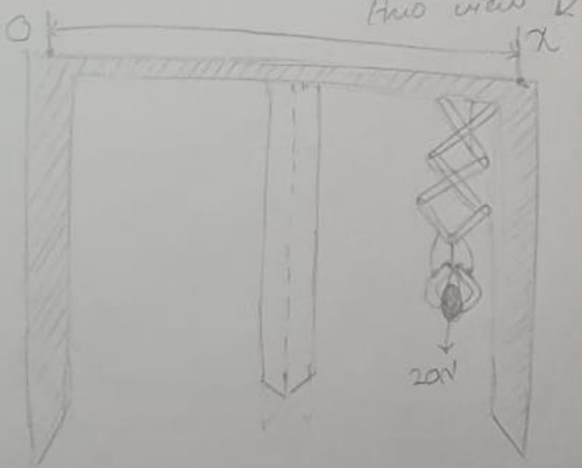
therefore the length will equal to

$OX = 500\sqrt{2} = 707.1\ mm$.



dimentions of the column $x = y = 20\ mm$

drawing from two view



assuming the force that is equal to 20 N is concentrated at one column @ the center of the column @ position X and calculating the the bending moment @ the center of column O, there fore the length will be = the diagonal of the structure − 2X half the diagonals of the 2 coulums to have it from center to center $= 500\sqrt{2} - 2 \times 10\sqrt{2} = 678.82\ mm$

and reducing the force into a force and moment due to moving the force from O to X will be:

@X: $F_A = 20 N$, $M_O = r_{OX} \times F_A = 678.82 \times 20 = 13.57645\ Nmm$

$$\boxed{M_O = 13.576\ N.m}$$

(2) Calculating the bending moment @ O [Calculating the Bending @ point P]

$$I = \frac{1}{12} bh^3 = \frac{20\sqrt{2} * (20\sqrt{2})^3}{12} = \frac{160000}{3} = 53333.33 \text{ mm}^4$$

There fore the total normal stress will be the already calculated normal Force [refer to Mile stone 1] + The stress due to Bending:

$$d = OP = 14.14\text{mm} \qquad \sigma = \frac{F}{A} + \frac{Md}{I} = \frac{20}{20 * 20} + \frac{13676 \times 14.14}{\frac{160000}{3}} \quad 3.65 \text{ MPa} > 1.48 \text{ MPa}$$

→ which is small compared to the ultimate normal strength very small so we will resize the dimentions of the column.

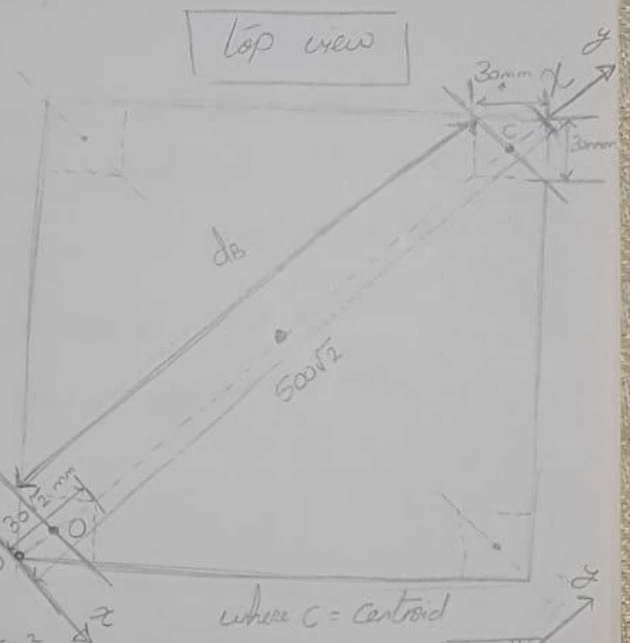
so resizing the dimensions of the Column to be 30 X 30 and Calculating accordingly:

→ diagonal of the column $= 30\sqrt{2}$
$= 42.43$ mm

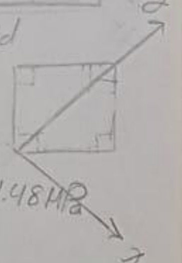
with diagonal equal to $500\sqrt{2}$ then the distance that we will Consider while calculating the moment:

$$M_O = 664.68 \times 30 = 13293.67 \text{ N.mm}$$

$$\boxed{\simeq 13.294 \text{ N.m}}$$



there for: $I = \frac{1}{12} bh^3 = \frac{30\sqrt{2} * (30\sqrt{2})^2}{12} = 270000 \text{ mm}^4$



$$\sigma = \frac{F}{A} + \frac{Md}{I} = \frac{20}{30 * 30} + \frac{13294 \times 21.21}{270000} = 1.067 \text{ MPa} < 1.48 \text{ MPa}$$

there for it is safe and can withstand the loads with no bending

③ Design   Calculating the max weight

$\sigma_{ultimate} = 1.48$ MPa [for Cardboard]

factor of safty $n = 2$ therefore: $\sigma_{all,\ plywood} = \frac{1.48}{2} = 0.74$ MPa

$$\sigma = \frac{F}{A} + \frac{Md}{I}$$

$$17.25 = \frac{F}{A} + \frac{\overbrace{[F * d]}^{M} \times OP}{I}$$

$$17.25 = \frac{F}{30 \times 30} + \frac{F * 664.68 \times 15\sqrt{2}}{270000}$$

$$\boxed{F = 13.875\ N}$$

$x = y = 30$ mm

$I = 270000$ mm^4

$d = 664.68$ mm

$OP = 15\sqrt{2}$ mm

$f = 2$

so the max load the column can withstand is 13.875 N with factor of safty = 2

and the value is reasonable as the used materials are light, and from milestone 1, the max weight will be ≃ 11 N, and the the weight of the material will not exceed 100 g which is 0.981 N there for the assumption of 20 N was redundant.

ADDITIONAL MATERIALS

❖ Motor used

Home — Servo Motors — Servo Motor (10 kg.cm - Metal Gear)

Servo Motor (10 kg.cm - Metal Gear)

LE 390.00

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This is a metal gear high torque servo motor. Metal gears allow increase servo reliability at high loads, making servo suitable for more critical applications. Unlike dc motors, with servo motors you can position the motor shaft at a specific position (angle) using control signal. The motor shaft will hold at this position as long as the control signal not changed. This is very useful for controlling robot arms, unmanned airplanes control surface or any object that you want it to move at certain angle and stay at its new position.

Specifications

Voltage	4.8 - 6 V
Speed	0.14 sec/60 degree (4.8V), 0.12 sec /60 degree (6v)
Torque	9 kg.cm (4.8V), 10 kg.cm (6 V), Stall torque
Dimension	40.0 x 20.0 x40.5 mm
Weight	56g
Horn Kit	Set of 4 pieces of arm servo horn with different sizes and shapes - 2 horn mounting screws, 4 servo mounting screws, 4 rubber vibration absorbers for servo mounting

[Servo Motor (10 kg.cm - Metal Gear) – Future Electronics Egypt (fut-electronics.com)]

❖ Maximum displacement of Z- Fork

For more details on the dimensions w and L please refer to the drawing in page 26.

length of the plunger (distance between the two links in the scissor mechanism)	length L (the length of one link is 100 mm)	the length of the whole fork (scissor system which consists of 2 and half links in each side, 5 links in total)	The displacement of the fork after the syringe was pushed 60 mm	the angle of the links with the horizontal
w	**SQRT(100^2 - w^2)**	**5*L/2**	**delta L**	**angle**
0	100	250	xxx	90
10	99.49874371	248.7468593	xxx	84.26082952
20	97.97958971	244.9489743	xxx	78.46304097
30	95.39392014	238.4848004	xxx	72.54239688
40	91.6515139	229.1287847	xxx	66.42182152
50	86.60254038	216.5063509	xxx	60
60	80	200	50	53.13010235
70	71.41428429	178.5357107	70.21114856	45.572996
80	60	150	94.94897428	36.86989765
90	43.58898944	108.9724736	129.5123268	25.84193276
100	0	0	229.1287847	0

Table (1)

w	L=SQRT(100^2 - w^2)	7*L/2	delta L	angle
0	100	350	xxx	90
10	99.49874371	348.245603	xxx	84.26082952
20	97.97958971	342.928564	xxx	78.46304097
30	95.39392014	333.8787205	xxx	72.54239688
40	91.6515139	320.7802986	xxx	66.42182152
50	86.60254038	303.1088913	xxx	60
60	80	280	70	53.13010235
70	71.41428429	249.949995	98.29560799	45.572996
80	60	210	132.928564	36.86989765
90	43.58898944	152.561463	181.3172575	25.84193276
100	0	0	320.7802986	0

Table (2)

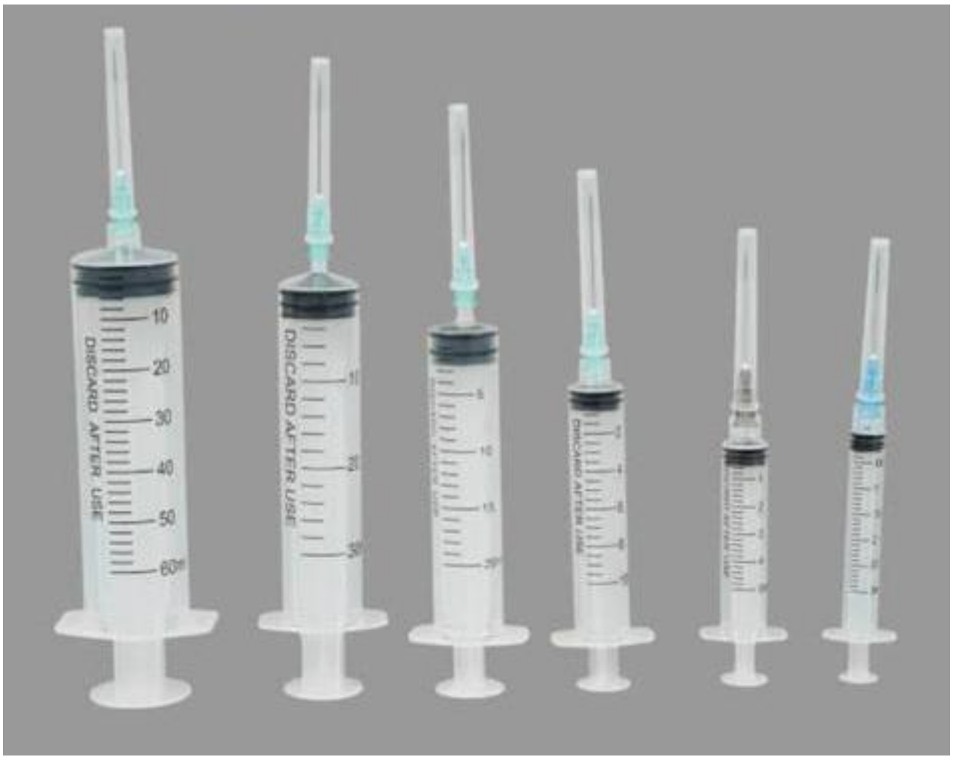
As the displacement found using 5 links is smaller than preferable, we will use instead 7 links to build the Z-fork in order to increase its total length.

To have the longest displacement, the initial position of the syringe will be such that the width of the scissor lift is 90 mm (collapsed state). Its length will therefore be around 152.5 mm with angle 25.84° between the links and the horizontal.

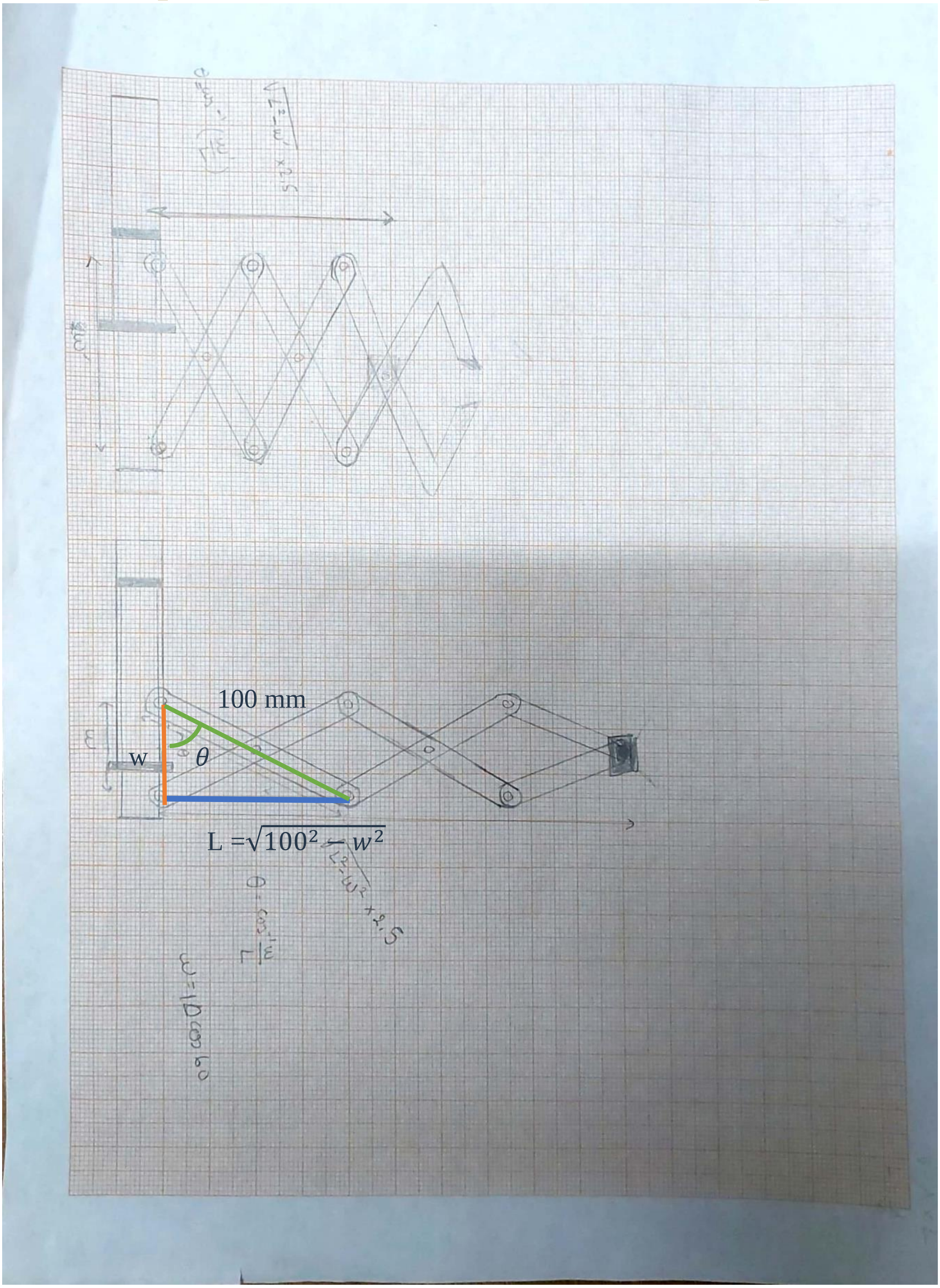
(A syringe with length ≥ 100 mm should be used)

The 600 mm length of the column and by consequence the whole structure will be divided into:

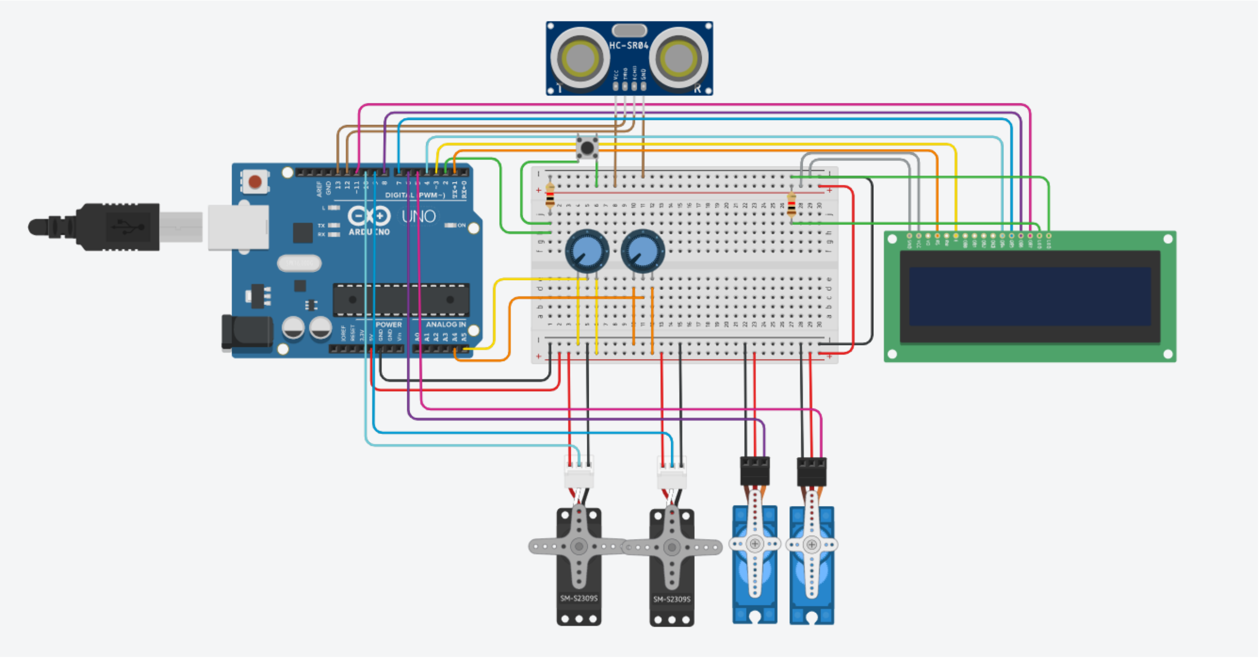
- 50 mm for the roof and its components
- 330 mm as the maximum length of the z-fork
- 130 mm for the grip
- 40 mm for the toys and the box



❖ A simplified look at the fork extended and collapsed



❖ A preliminary version of the Arduino circuit to be implemented



Kindly note that it is not the final version that will be used as it is still under development and editing.

❖ A preliminary version of the Arduino code:

```
#include <LiquidCrystal.h>
const int rs = 1, en = 3, d4 = 4, d5 = 7;
const int d6 = 8, d7 = 11;
LiquidCrystal lcd (rs, en, d4, d5, d6, d7);

#include <Servo.h>
Servo servo1; //X fork
Servo servo2; //Y fork
Servo servo3; //Z fork
Servo servo4; //Gripper
int pos1;
int pos2;
int pos3;
int pos4;

int potX = A5;
int potY = A4;
int push = 2;
int valX;
int valY;
int valP;

#define trig 13
#define echo 12
long duration, distance;
```

```
int turn = 1; //true

void setup() {
  servo1.attach(10);
  servo2.attach(9);
  servo3.attach(6);
  servo4.attach(5);

  pinMode (push, INPUT);
  pinMode (potX, INPUT);
  pinMode (potY, INPUT);

  pinMode (trig, OUTPUT);
  pinMode (echo, INPUT);

  Serial.begin(9600);

  lcd.begin(16,2);
  lcd.print("Starting your turn!");
  lcd.setCursor(3,1);
  lcd.print("Enjoy!! :D");
}

void loop() {

  while (turn)
```

```
{
  Serial.println("NORMAL");

  valX = analogRead(potX);
  valY = analogRead(potY);
  valP = digitalRead(push);
  valX = constrain(valX, 0, 180);
  valY = constrain(valY, 0, 180);

  if (valP == HIGH)
  {
    Serial.println("DONE");
    grab();
    delay(500);
    goBackToPos0();
    delay(500);
    findingPrize();
    delay(100);
    checkWin();
    turn = 0;
    Serial.println("END");
    delay(1000);
  }
  else
  {
    servo1.write(valX);
    servo2.write(valY);
```

```
      delay(15);
    }

  }

  valP = digitalRead(push);
  if (valP == HIGH)
  {
    Serial.println("NEW");
    turn = 1;
    delay(1000);
  }
  delay(50);
}



void checkWin(){

  Serial.println("CHECK");

  lcd.setCursor(0,0);
  if (distance < 5)
  {
    lcd.print("YOU WON!!!!");
    for (int i =0; i < 15; i++)
    {
      lcd.scrollDisplayLeft();
```

```
    delay(200);
  }
 }
 else
 {
  lcd.print("SORRY! YOU LOST :(");
  for (int i =0; i < 15; i++)
  {
    lcd.scrollDisplayLeft();
    delay(200);
  }
 }
}

void findingPrize()
{
 Serial.println("FINDING");

 digitalWrite(trig, LOW);
 delayMicroseconds(2);
 digitalWrite(trig, HIGH);
 delayMicroseconds(10); //periode d'onde
 digitalWrite(trig, LOW);
 /* what we do eno bnhadi 7aga basita ba3diha
 bn5ali ybda2 mn awel onde b periode 10 µs
 ba3diha ta7t el echo hay7sb el wa2t el a5adto*/
 duration = pulseIn(echo, HIGH); // micro
```

```
  /* d = t * V
   distance = duration / 2 (3a4an ray7 w rage3)
   * 344 (vitesse du son) * 100 (m to cm pour v)
   / 1000000 (µs to s pour t); so we get in cm*/
  distance = duration * 0.0172; //to get it in cm
  //return distance;
}

void goBackToPos0(){

  Serial.println("GOBACK");

  for (;pos3 >=0;pos3--) //Z fork first
  {
    servo3.write(pos3);
    delay(15);
  }

  for (;pos1 >=0;pos1--) // X fork
  {
    servo1.write(pos1);
    delay(15);
  }
  for (;pos2 >=0;pos2--) // Y fork
  {
    servo2.write(pos2);
    delay(15);
```

```
  }

  for (;pos4 >=0;pos4--) //the gripper to open
  {
    servo4.write(pos4);
    delay(15);
  }
}

void grab(){

  Serial.println("IN GRAB");

  for (pos3 = 0;pos3 <=180;pos3++) //Z fork first
  {
    servo3.write(pos3);
    delay(15);
  }
  for (pos4 = 0;pos4 <=180;pos4++) //the gripper to hold
  {
    servo4.write(pos4);
    delay(15);
  }

}
```