# Kinematics

- Main Task: **Gripper mechanism for lifting bricks**
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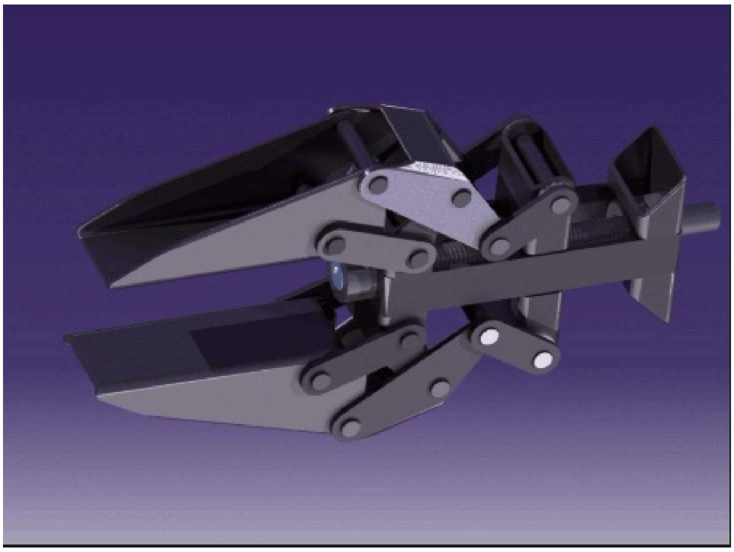
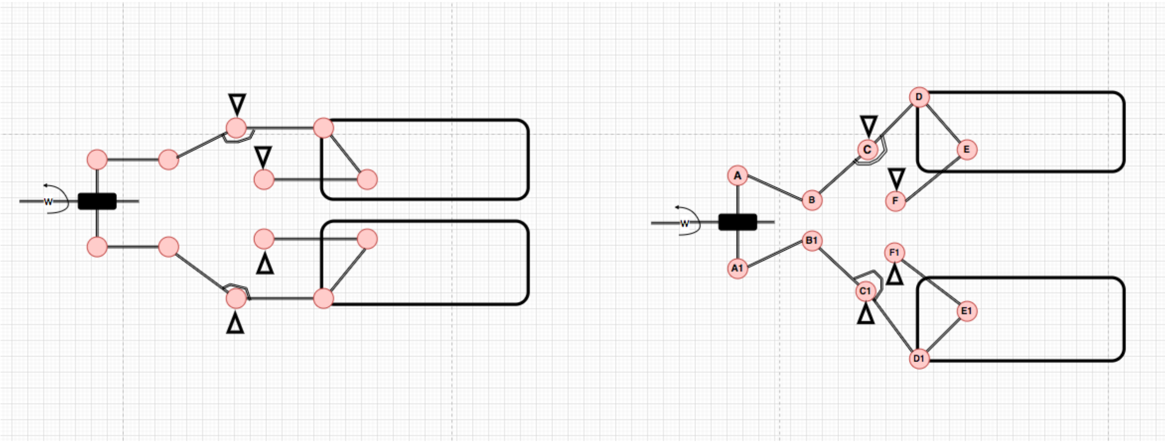
## Gripper



**Need to consider:**

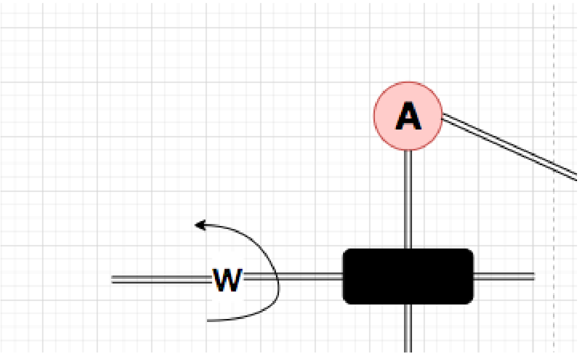
- torque of the motor;
- how the torque is passed on;
- resultant force of the grip;
- robustness of the material.

## Gripper Structural Analysis

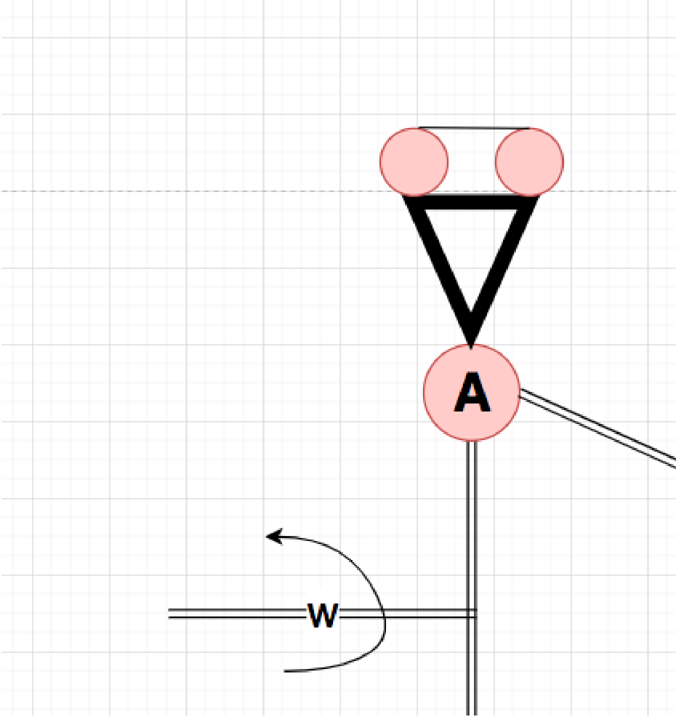



**Some remarks:**

- Left picture shows the starting position of the gripper and its joints and links
- Pictures are not drawn to exact scale and serve as a sketch reference for better understanding
- CD || FE (same for bottom side, as the gripper is symmetrical)
- Joint B can not be raised higher than on 1st picture (0 degree with X axis)
- Motor has predefined angular velocity w
- Kinematic Pairs/And Links:
  - A: OA-AB
  - B: AB-BC
  - C: BC-CD
  - D: CD-DE
  - E: DE-FE
  - F: ground - FE
- Trajectories (for top half):
  - line: OA (OA + A1O= AA1)
  - circle: FE
  - complex curve: BC, AB, CD, DE
- Compared to the previous version of a diagram, joint A was changed to look like this:

  Instead of this:

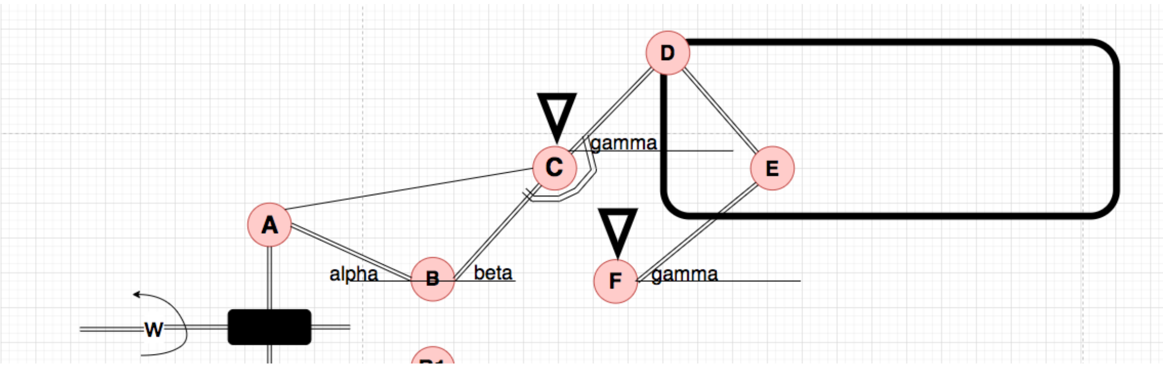


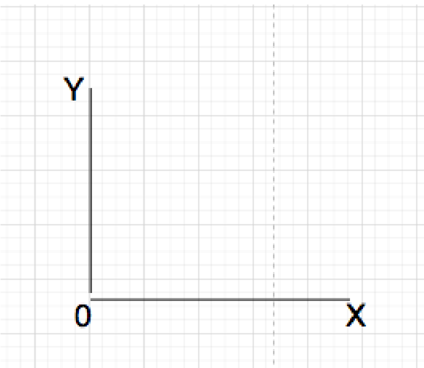

We choose the upper design because it looks simpler, and thus, more understandable.
In addition to that, we described main axle movement as a Ball Screw pair(BSP). For now it is simpler to model and account for, but in the future we might switch to Nut Screw pair, as it is cheaper.

- number of links: 7, moving links: 6

## Gripper Kinematic Analysis

Fot that part we will analyse only upper part of mechanism, as gripper is symmetrical. All calculations for the lower part would be the same:




*We assume for our simplicity that center of the coordinate frame at the center of link AA1.*

### Goal:

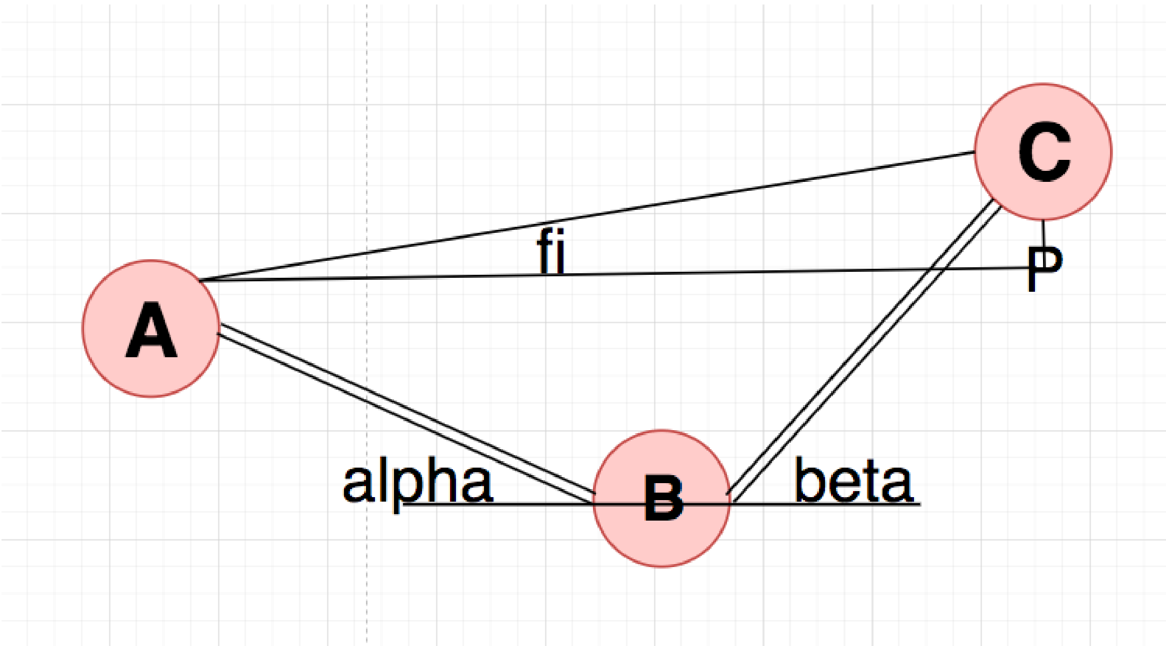
**We want to know the dependencies between $w$ - angle of bolt rotation and also generalized coordinates AND position, velocity, acceleration of joint E.**

- **(The law of motion of point E as a engine angle function).**

## What we know:

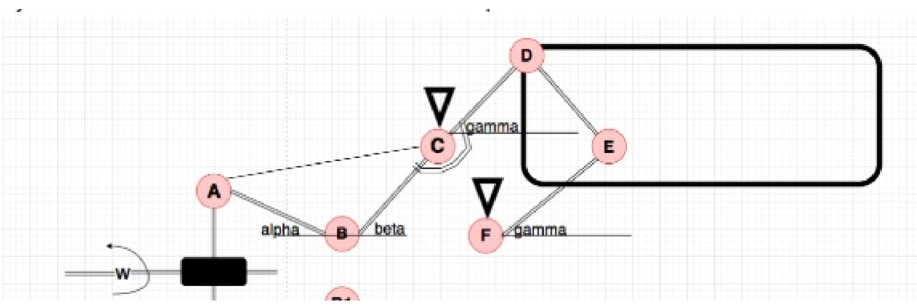
- Positions of non-moving joints (C and F)
- Position of all joints in initial state ($time=0$)
- Lengts of all links
- Angular velocity of motor(we assume it can be 10 - rad/sec = 1.5 rotation per sec)
- Change in angle of motor, we think that it's$w$
- h - step screw thread

We will find β, γ and $\alpha$ just for simplicity of showing calculation step, we know there are all depend on angle of rotation of the motor.




For the sake of simplicity of calculations and understanding we add a line CP which is perpendicular to OX axis. CP length is known by design, as point C is not moving. And so: $CP = cY - aY$

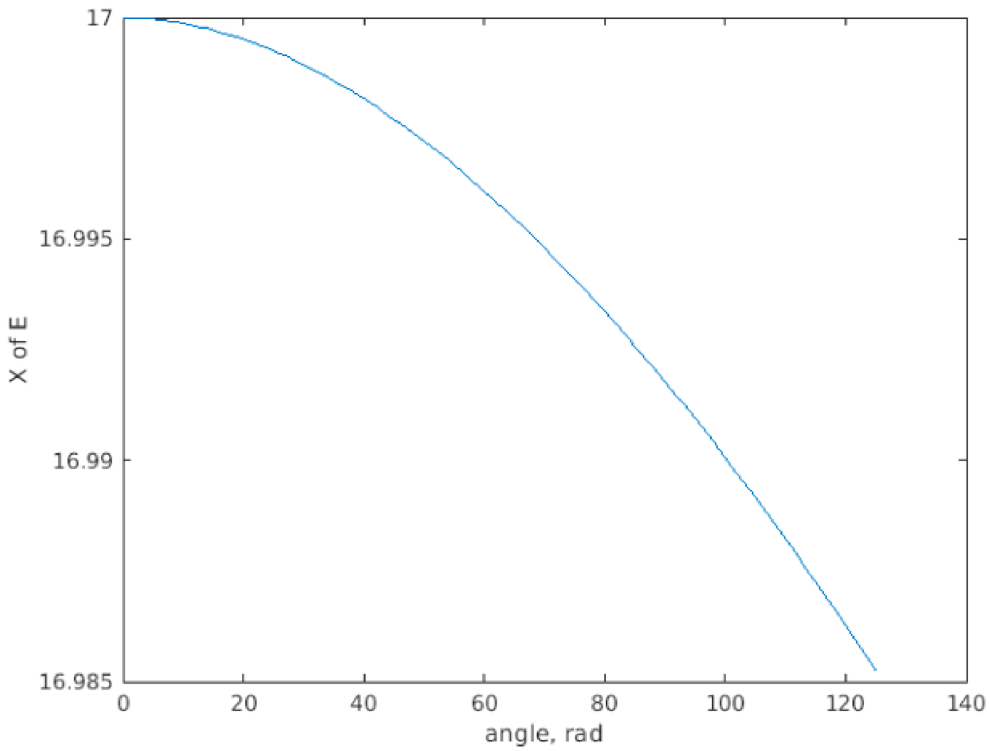
## Steps towards the goal:



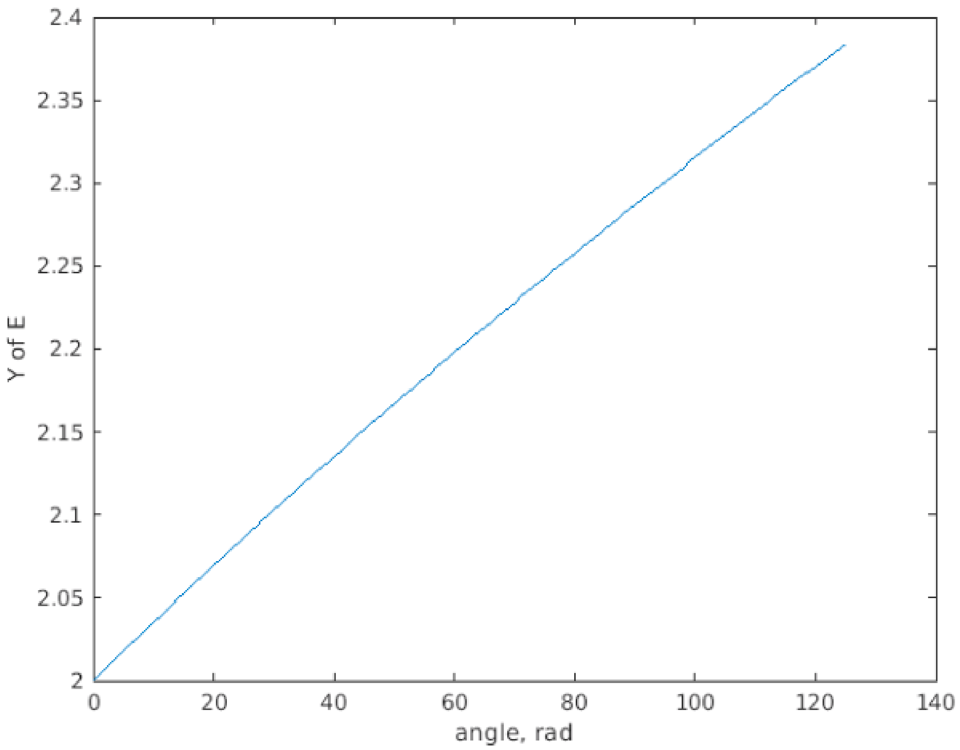

- $AA1$ link moves to a positive side on$OX$ and can be expressed by equation: $aX = x0 + w/(2*pi)*h$
  - Where $aX0 = 0$, by assumption of center of coordinates frame
- From triangle APC:

$AC=\sqrt{(PC*PC+AP*AP)}$ $\varphi=atan(\frac{CP}{AP})$ where $AP=cX-aX$;

- Triangle ABC:
  - by cosine theorem $B=acos(\frac{AB^2+BC^2-AC^2}{2AB*BC})$
  - by sine theorem $A=asin(\frac{sin(B)*BC}{AC})$ $\alpha=A-\varphi$ $\beta=180^{\circ}-B-\alpha$
- Rotation of the link BCD, and thus, angle $\gamma$. $\gamma=\beta-\beta_0$
  - where $beta0=asin(\frac{PC}{BC})$
- We initialize some parameters, just to visualize calculations:
  - $PC=3;h=2;$
  - $OA=10;AB=5;BC=AB;DE=AB;CD=DE$
  - $aX0=0;beta0=asin(PC/BC);FE=5$
  - $cX=AB+sqrt(BC^2-PC^2);cY=OA+PC;aY=OA;$
  - $fX=10;fY=2;$
- So now we are ready to find the changing in position of point E: $eY=fY+FE*sin(gamma)$

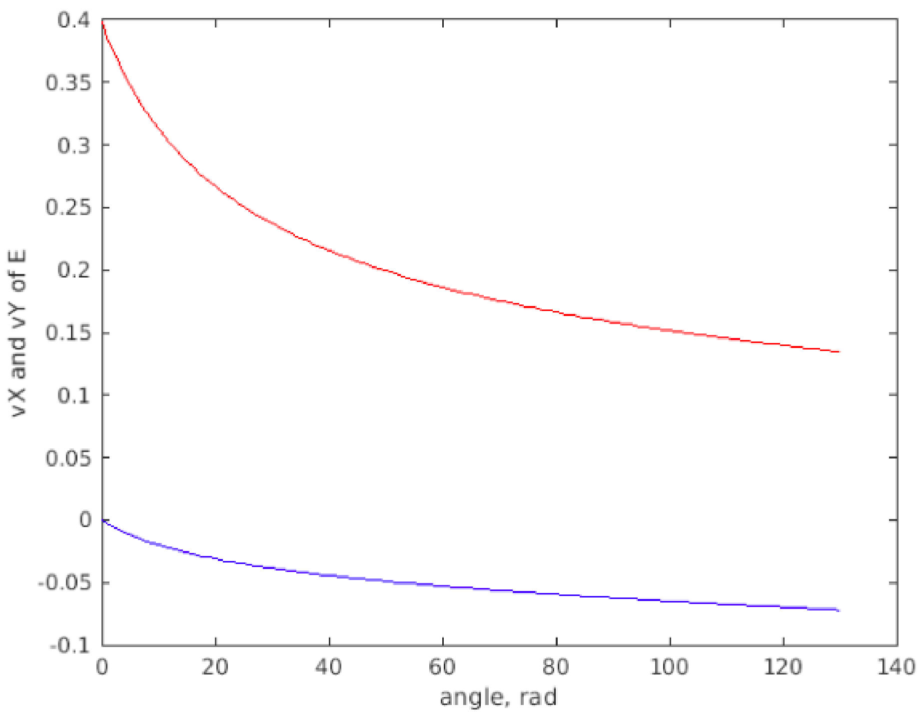



$eX=fX+FE*cos(gamma)$




Velocity and acceleration of point E can be found by differentiating of the existed equations for X and Y, and if in the future we will need V and A for point E, we can just make squared sum for X and Y components.

- And so velocity of point E(red - for X, blue - for Y):

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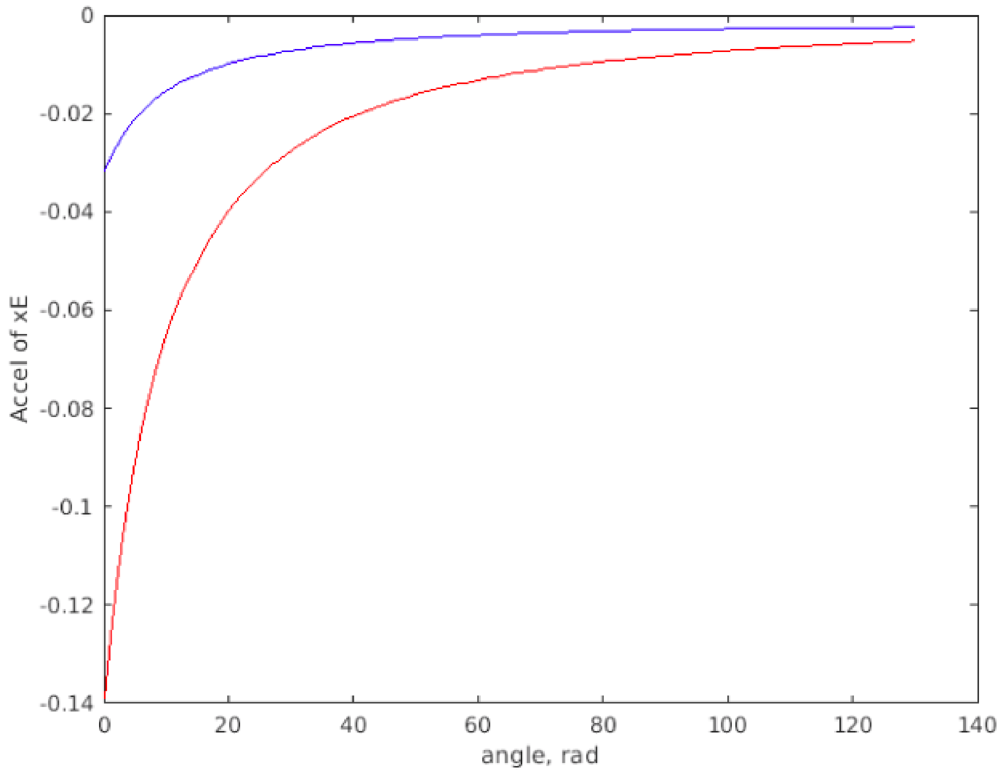
- And acceleration (red - X, blue - Y direction)




Thus, we found out how to get the position of point E relative to the position of angle of the motor.

## Choose lengths for gripper links(rules)

- *And we know that* $CD=FE$ *and they are parallel, and also* $BC=CD$*.*
- *Distance between EE1 in initial state about 130(as brick size) and in close state 120.*More about it next iteration.
- We have one issue in calculations, we think as initial state closed gripper, to change the process of calculations we need only in change in code from:

  $aX=x0+w/(2*pi)*h$

  to:

  $aX=x0-w/(2*pi)*h$

## Stopping conditions:

Will be considered next iteration of project.

## Conclusion

We have understood how the mechanism works (having a gif was helpful enough), drawn its kinematic diagram and performed kinematic analysis. Next step of our work would be to perform dynamic analysis of our gripper.

You can find the Matlab code for kinematics in the file**KinematicsGripper.m**: https://github.com/Gfycyd/MechanicsMachines