Mechanics & Machines Course

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Bird Wing Simulation

CAD & Dynamics

Report

Presented To: **Oleg Bulichev**

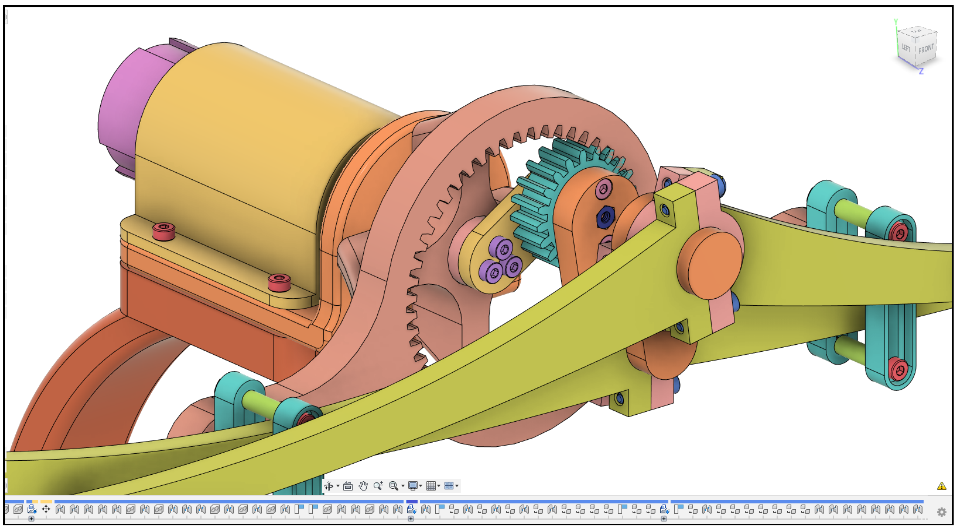
Introduction

Our goal is to **design** a mechanism that simulates the motion of the bird wing. Then solve the **dynamics** of the mechanism to find the required torque from the motor to derive the mechanism according to the desired motion. The tools used are Fusion360 and Ansys workbench.

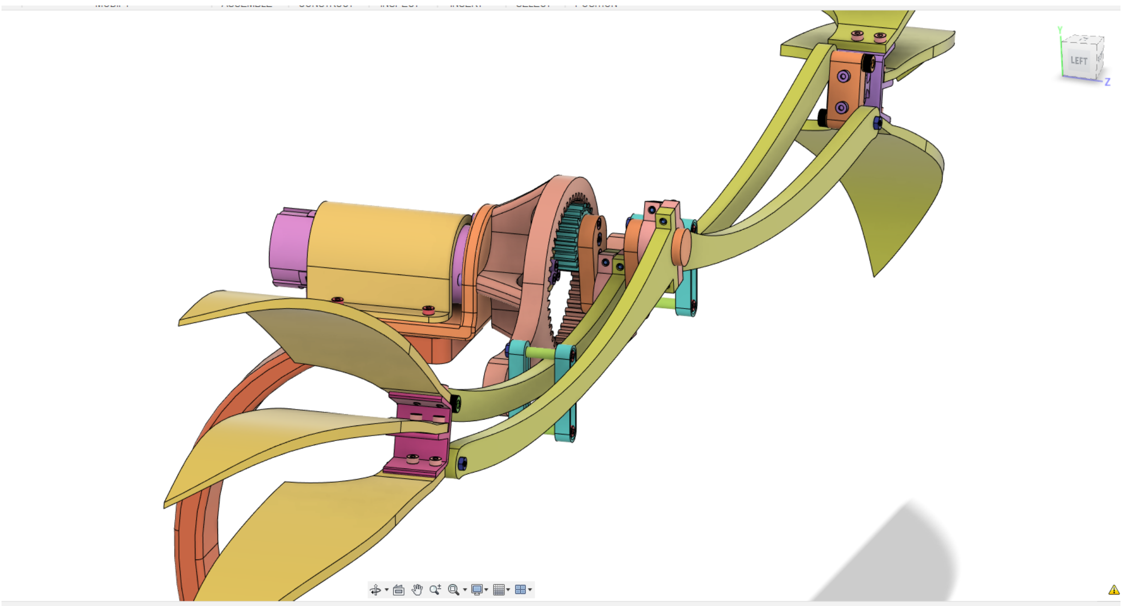
Design View

As discussed earlier in the kinematics part, the mechanism is composed from three parts, planetary gear, four-bar linkage and five-bar linkage. so the motion will be as following:

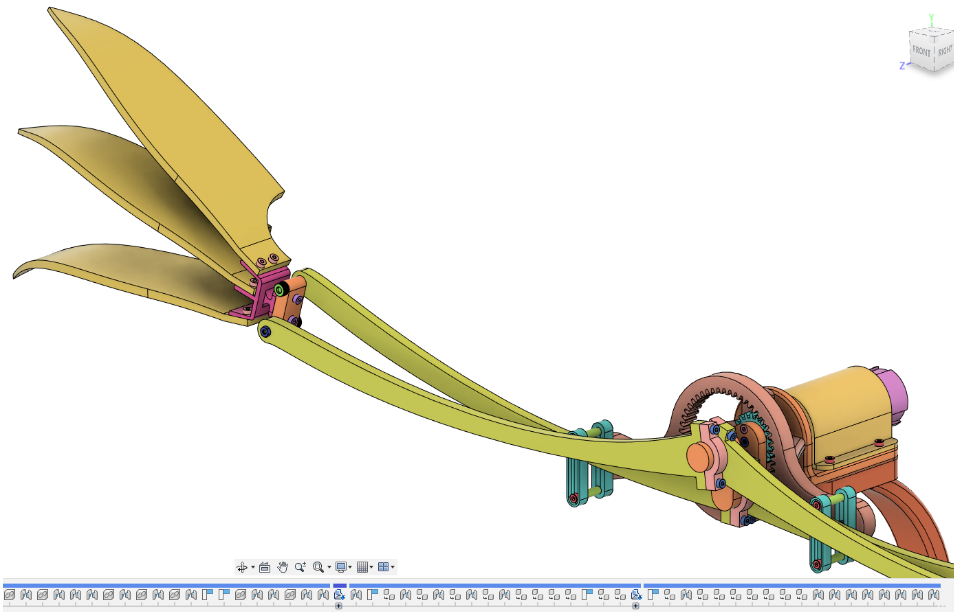
- The motor will derive a shaft that is connected to the center of the planetary gear, the shaft will rotate the spur gear inside the ring gear, which makes the spur gear rotate around itself as a consequence.



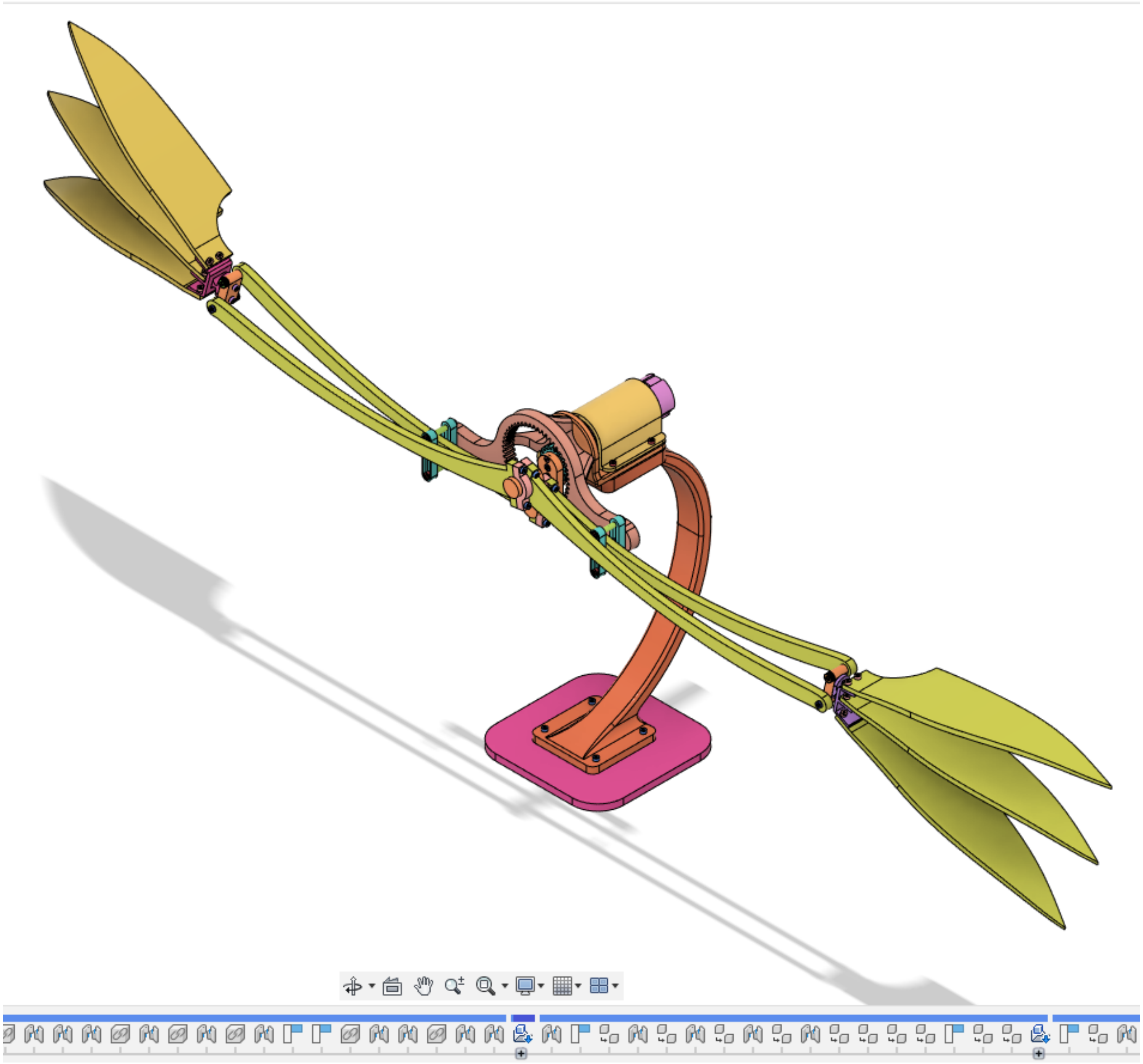
- The spur gears is connected to a part that divides the links into two groups, one group rotates with the center of the spur gear(with the motor shaft rotation), and the other group rotates with the spur gear rotation.



- The back links move through sliders to prevent it from falling down and restrict their motion, in order to give the desired motion.
- The end of each two links (left and right) are connected to rotates according to each other motion, hence the wings move smoothly simulating the motion of a real bird wing.



- Here is an image view the full mechanism:

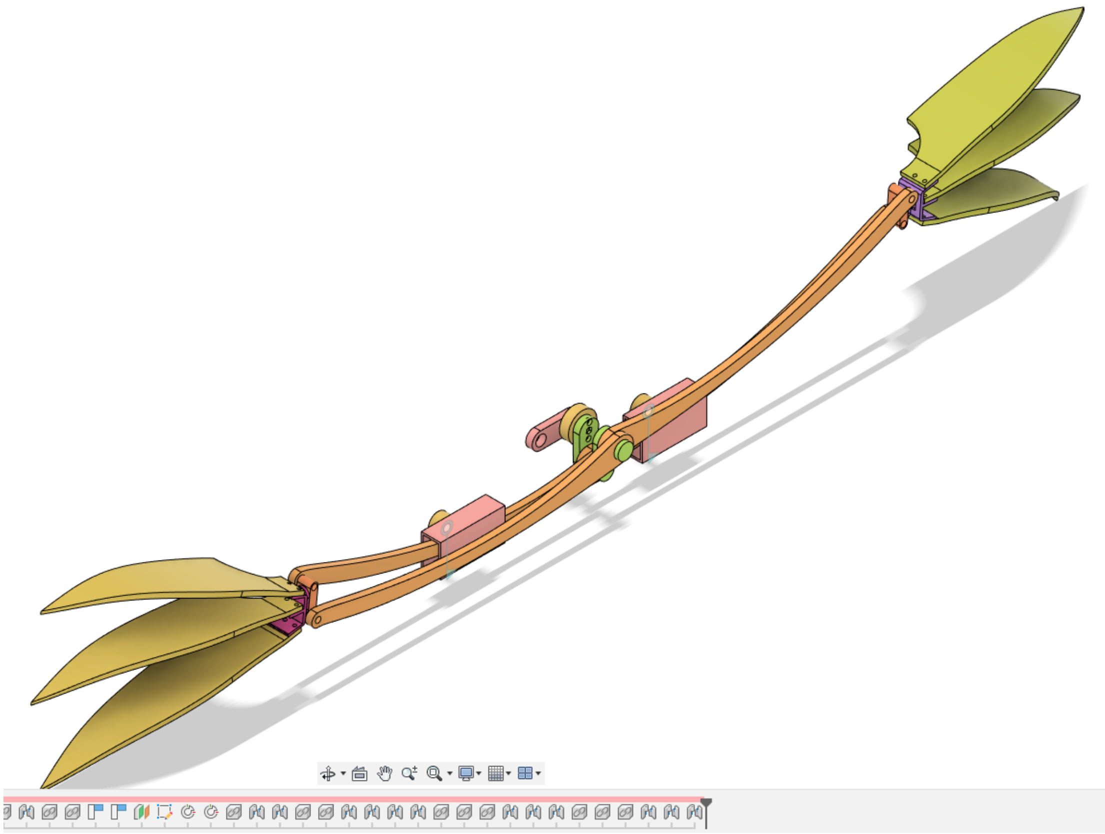


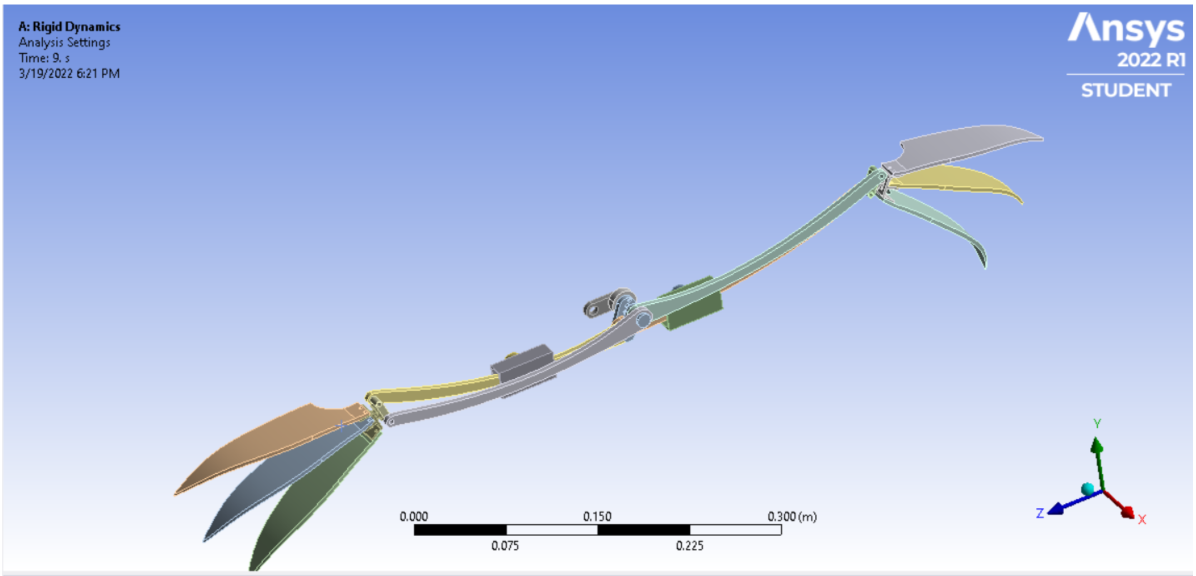
Dynamics

To obtain the necessary torque to derive the mechanism according to the desired motion, I used Ansys with simplified model of the mechanism.

Ansys Model:

- Here is the simplified mechanism (in Fusion360 & Ansys):





Ansys Setup:

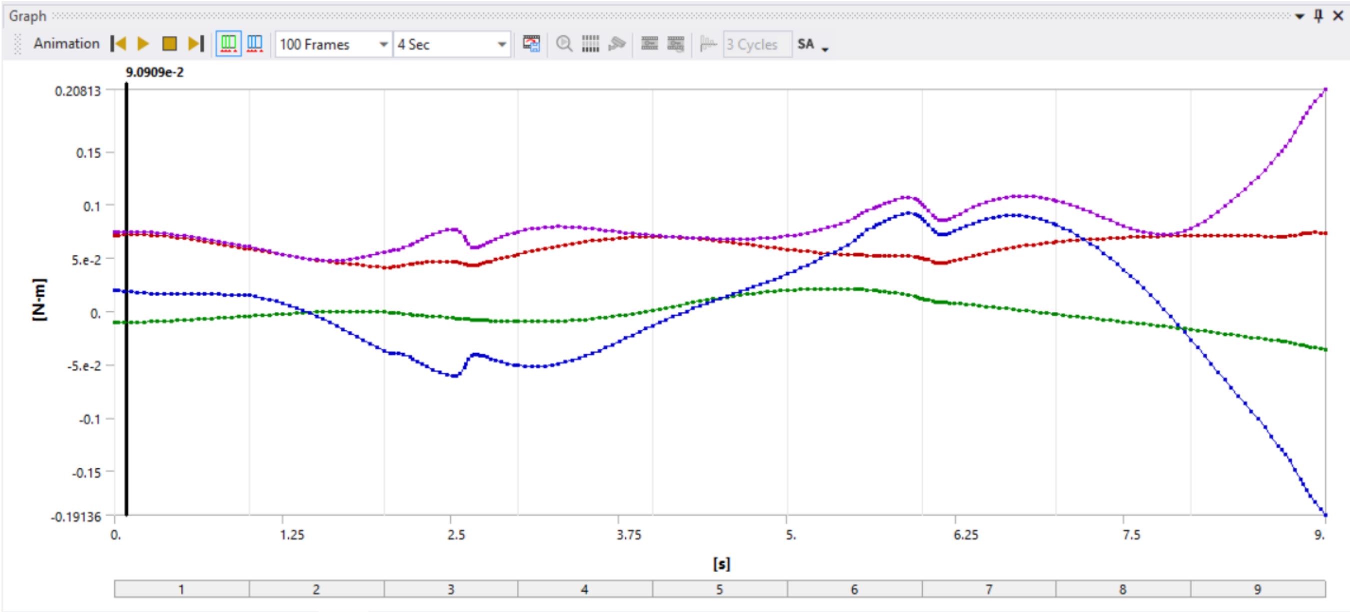
- The force which affects the mechanism is gravitational force directed in negative $Y\ axis$. The friction forces can be neglected, due to its extreme difficulty to calculate <u>accurately</u> and due to the smooth surfaces and enough tolerances between the parts (also lubrication might be added in the real mechanism).
- Setting the input angular velocity to $\frac{1}{9}\ rad/s$ to the joint that represent the motor

shaft.

- Setting the angular velocity of the spur gear to $\frac{7}{3} \times \frac{1}{9} = \frac{7}{27}\ rad/s$, since $\frac{7}{3}$ is the gear ratio.
- Solve for the total torque in the input joint.

Ansys Solution Results:

- The maximum torque obtained is $0.20813\ N.m$ and the minimum was $-0.19136\ N.m$.
- Here is the result plot:
- The red color indicates the total toque in $x-axis$, the green color indicates the total toque in $y-axis$, the purple color indicates the total toque in $z-axis$, the Violet color indicates the overall toque.



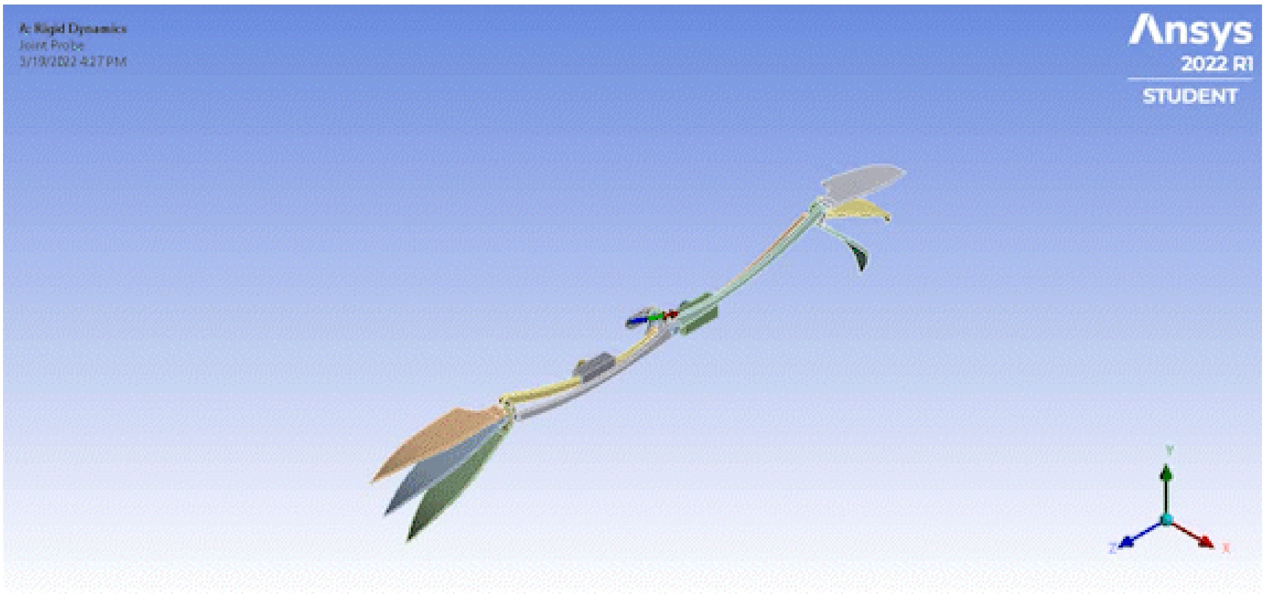
- some of the obtained torque data:

Tabular Data

	Time [s]	Joint Probe (Total Moment X) [N·m]	Joint Probe (Total Moment Y) [N·m]	Joint Probe (Total Moment Z) [N·m]	Joint Probe (Total Moment Total) [N·m]
1	0.	7.1114e-002	-1.1066e-002	1.9884e-002	7.4666e-002
2	1.e-002	7.1186e-002	-1.1046e-002	1.9728e-002	7.469e-002
3	3.e-002	7.1313e-002	-1.0999e-002	1.9423e-002	7.4725e-002
4	7.e-002	7.1502e-002	-1.0885e-002	1.8843e-002	7.474e-002
5	0.12	7.1618e-002	-1.0704e-002	1.8183e-002	7.4661e-002
6	0.17	7.1603e-002	-1.0483e-002	1.7604e-002	7.4477e-002
7	0.22	7.1461e-002	-1.0227e-002	1.7111e-002	7.4189e-002
8	0.27	7.1199e-002	-9.94e-003	1.6706e-002	7.3805e-002
9	0.32	7.0821e-002	-9.6275e-003	1.6386e-002	7.3327e-002
10	0.37	7.0335e-002	-9.294e-003	1.6146e-002	7.2761e-002
11	0.42	6.9749e-002	-8.944e-003	1.5979e-002	7.2113e-002
12	0.47	6.9071e-002	-8.5819e-003	1.5873e-002	7.1389e-002
13	0.52	6.8309e-002	-8.2119e-003	1.5815e-002	7.0595e-002
14	0.57	6.7472e-002	-7.8376e-003	1.579e-002	6.9737e-002
15	0.62	6.6569e-002	-7.4623e-003	1.5783e-002	6.882e-002
16	0.67	6.561e-002	-7.0888e-003	1.5778e-002	6.7851e-002
17	0.72	6.4602e-002	-6.7196e-003	1.5757e-002	6.6835e-002
18	0.77	6.3556e-002	-6.3566e-003	1.5703e-002	6.5775e-002
19	0.82	6.2479e-002	-6.0014e-003	1.5602e-002	6.4677e-002
20	0.87	6.138e-002	-5.6552e-003	1.5437e-002	6.3544e-002
21	0.92	6.0267e-002	-5.3191e-003	1.5195e-002	6.238e-002
22	0.97	5.9145e-002	-4.9938e-003	1.4863e-002	6.1188e-002
23	1.	5.8472e-002	-4.8039e-003	1.4615e-002	6.0462e-002
24	1.	5.8371e-002	-4.7849e-003	1.4588e-002	6.0356e-002
25	1.05	5.7218e-002	-4.3312e-003	1.3445e-002	5.8936e-002
26	1.1	5.6076e-002	-3.8879e-003	1.2142e-002	5.7507e-002
27	1.15	5.4952e-002	-3.4573e-003	1.067e-002	5.6085e-002

Selection Information Messages Tabular Data Graph

- Here is an Illustration of the motion.



Conclusion

In conclusion, we have discussed the mechanism design details on Fusion360, solved its dynamics on Ansys, and obtained the required torque to derive the bird wing motion as shown above.
