2025

Study of a landing gear

MULTIBODY DYNAMICS SIMULATION

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Introduction

This practical work focuses on studying the **landing gear of a fighter jet**, a system responsible for supporting the aircraft during take-off, landing, and ground operations. In this practical work we focus on how **Retraction and Extension** meaning how the landing gear folds and unfolds during flight using controlled movements and **Landing Impact** where we Analyse how the landing gear absorbs the shock when the aircraft touches the ground.

I. Kinematic joint control for landing retraction and extension

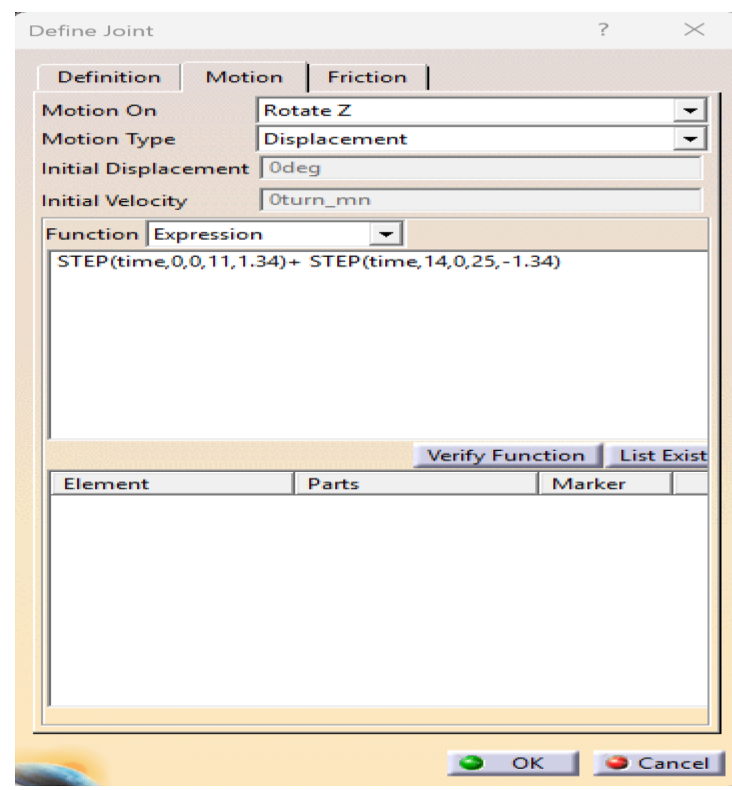
Q1. What is the STEP function you should write to control 01-Frame kinematic joint as indicated.

The first step must start at 0 second and must finish at 11 seconds 77 degrees

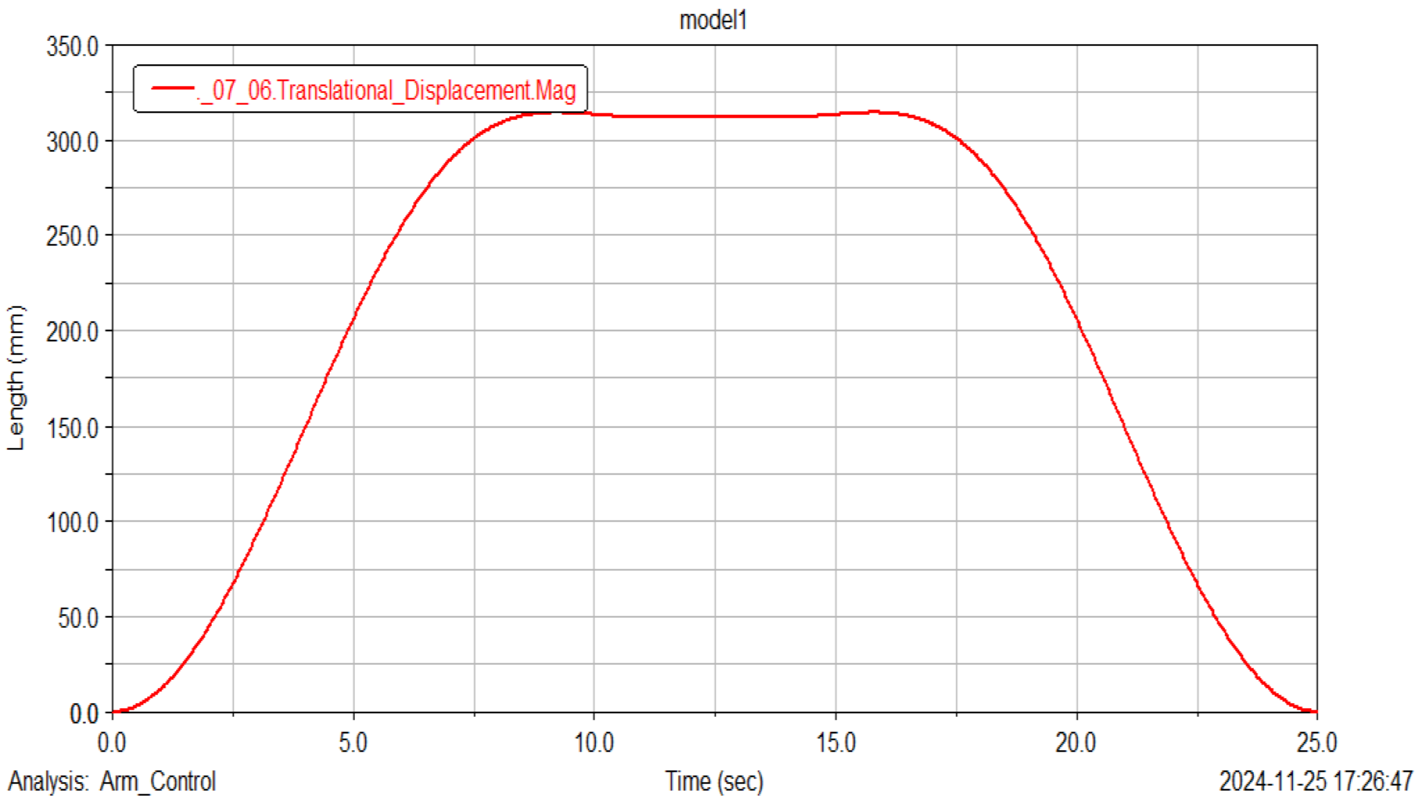
The second step must start at 14 seconds with 77 degrees and must finish at 25 seconds with 0 degrees

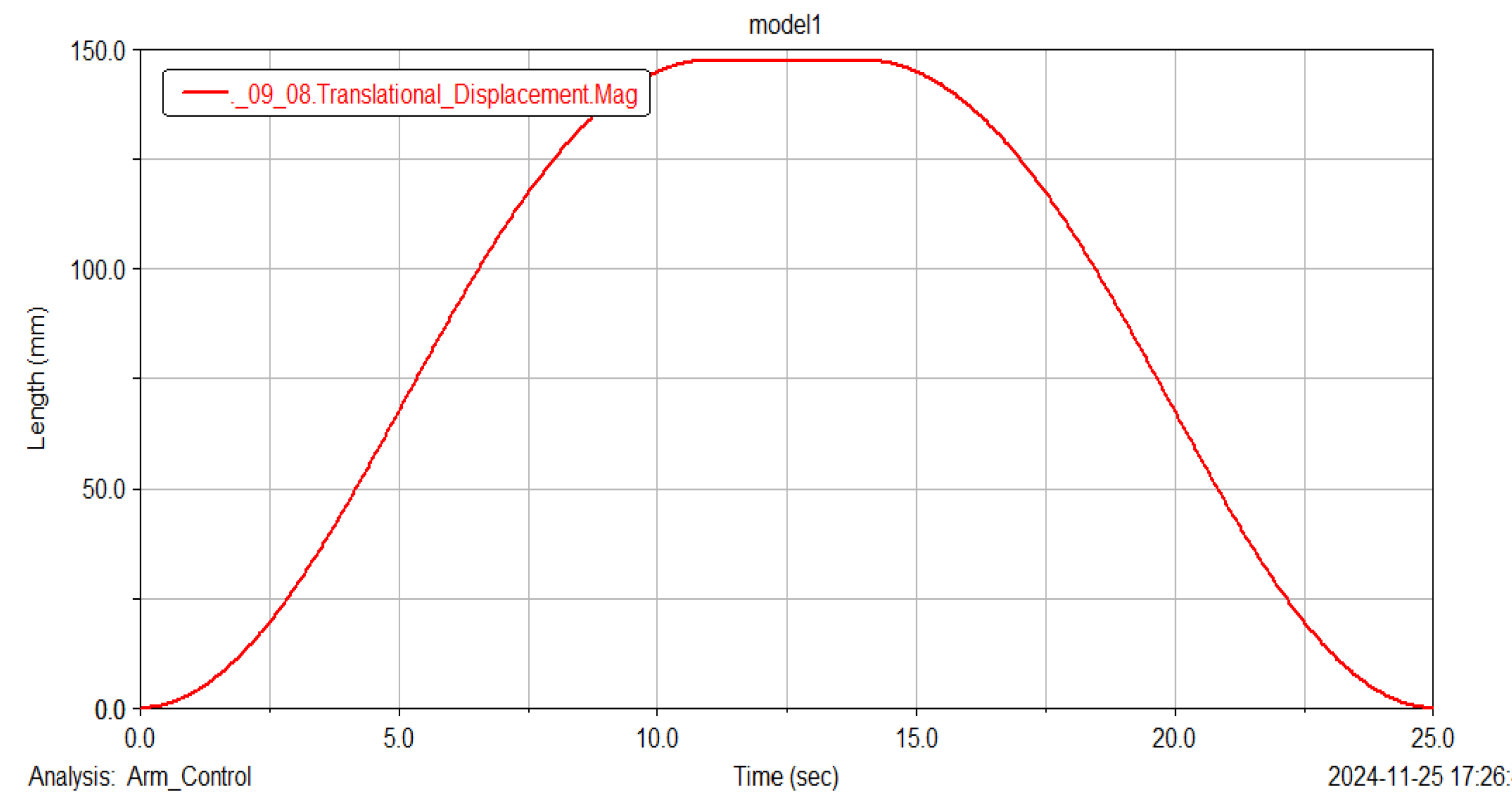
STEP (time,0,0,11,1.34) + STEP (TIME,14,0,25, -1.34) (angles in radius)

Q2. Determine the displacement amplitude of 06-07 and 08-09 actuators during this motion



To determine the displacement amplitude of 06-07 and 08-09 actuators during the motion of the bras we implemented the expression of the joint Function motion and done run the simulation and plot the graphs.





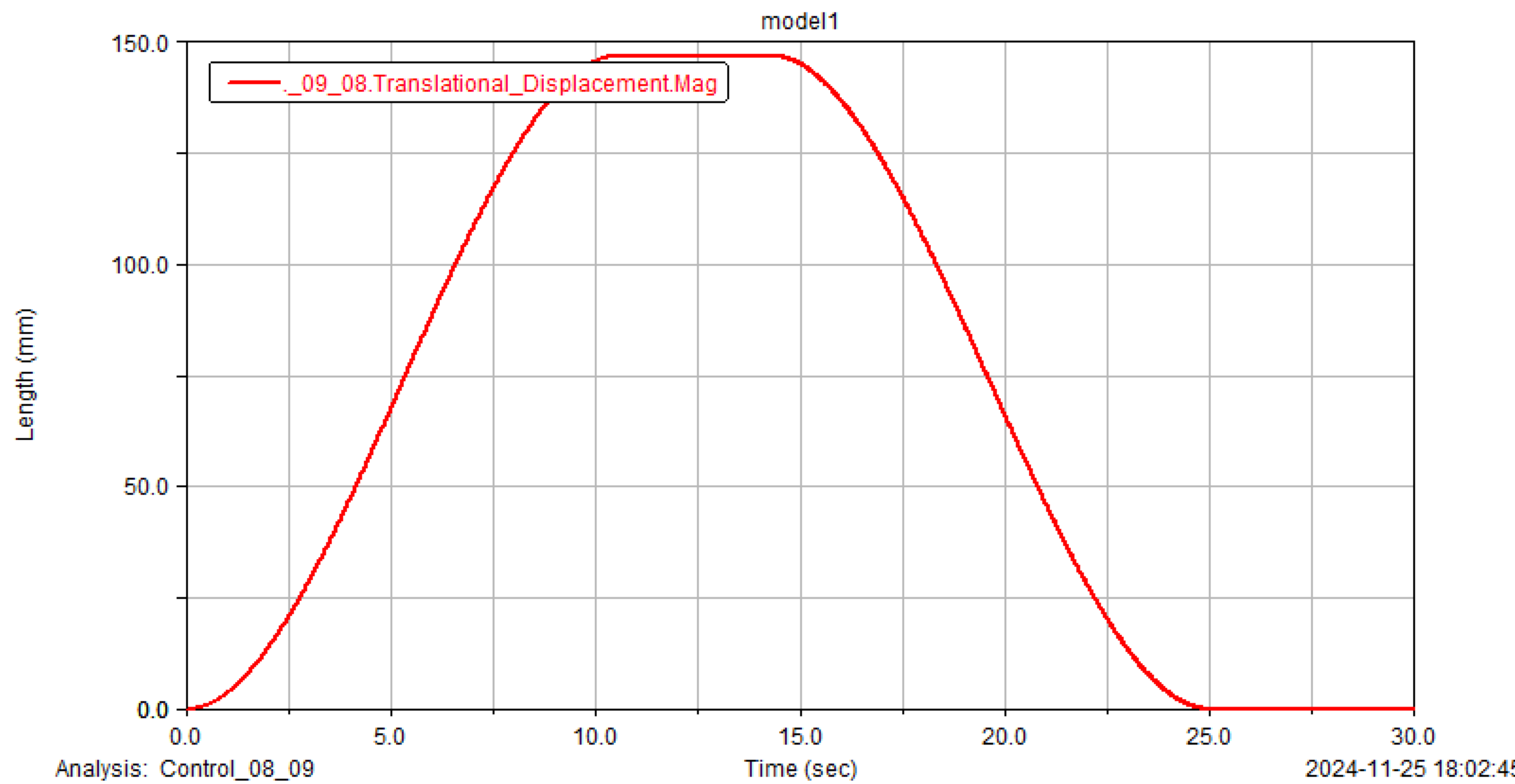
Now we investigate the possibility of controlling the **08-09** actuator instead of the arm **01** for the retraction and extension of the landing gear.

So, we Created the control of **08-09** actuator allowing to get the same landing gear initial and final positions from the previous question and run a simulation named '08_09_Actuator_Control'.

Q3. What are the parameters used to control 08-09 actuator?

Step function (length) We get this step function from the graph of 08-09 plotted while controlling with the Bras- 01

STEP (time,0,0,10.55,146.92) + STEP (time,14.25,0,25, -146.92)



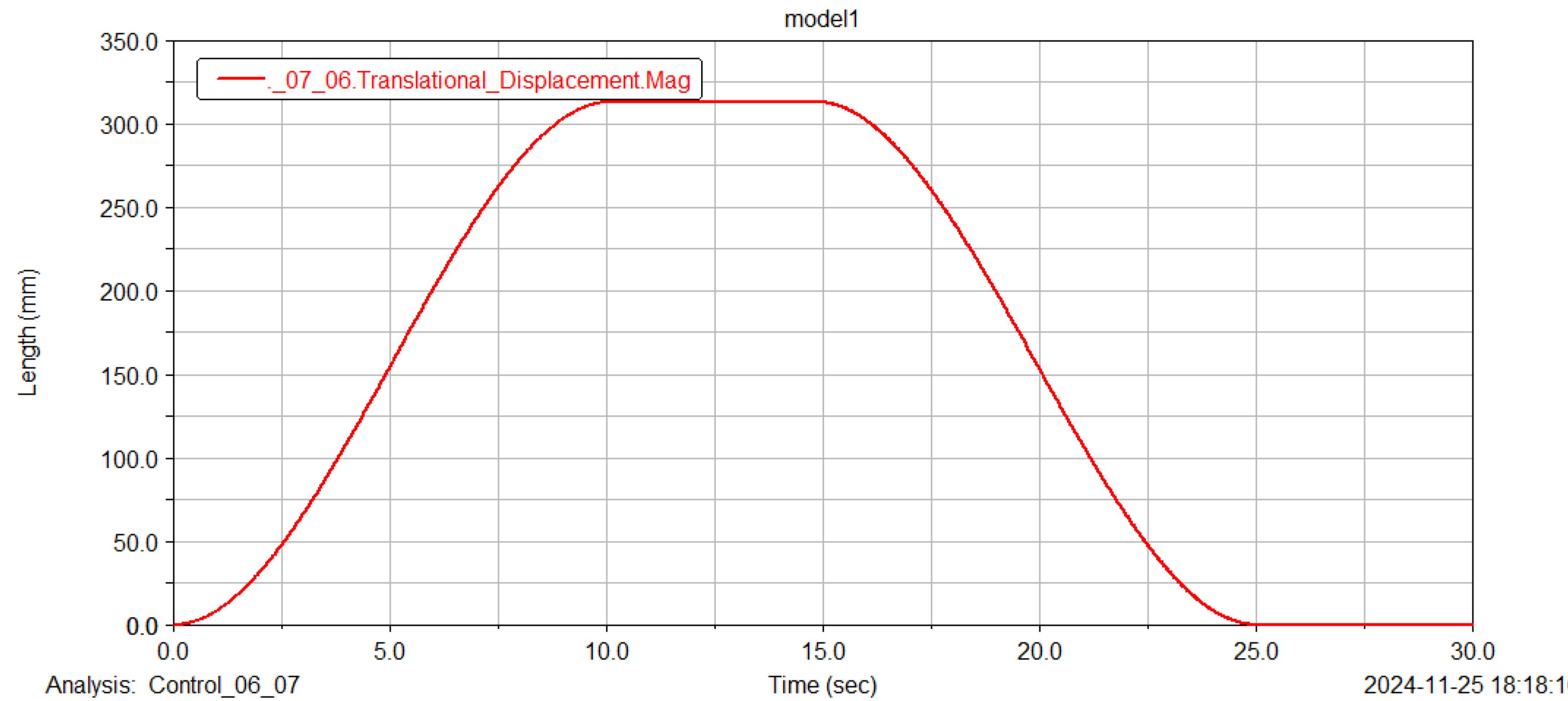
Investigating the possibility of controlling the **06-07** actuator instead of the Arm **01** for the retraction and extension of the landing gear.

Create the control of **06-07** actuator allowing to get the same landing gear initial and final positions from the previous question and run a simulation named '06_07_Actuator_Control'.

Q4. What are the parameters used to control 06-07 actuator?

Step function (length) Step function (length) We get this step function from the graph of 06-07 plotted while controlling with the Bras- 01

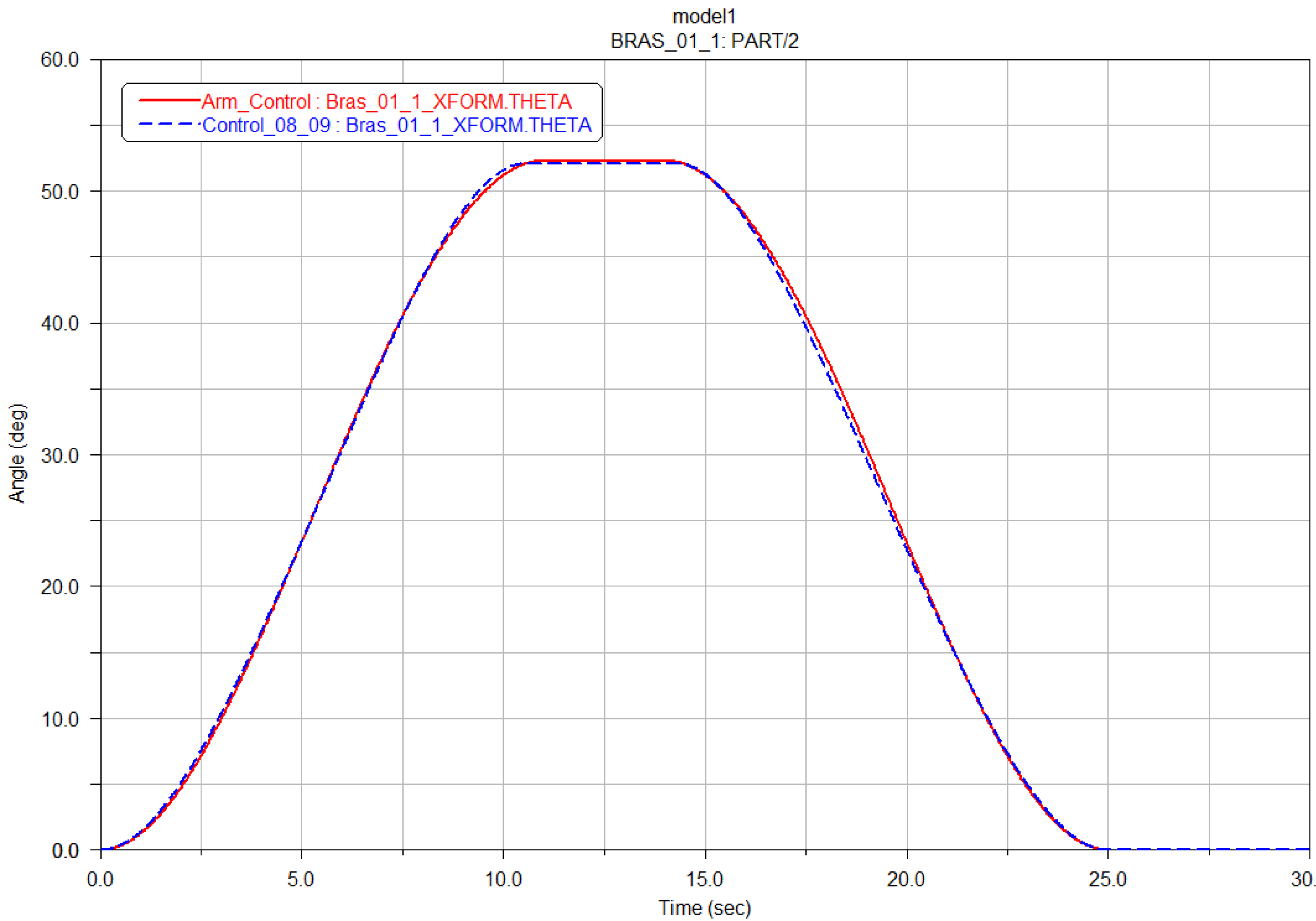
STEP (time,0,0,10.05,313.0946) + STEP(time,14.85,0,25,-313.0946)



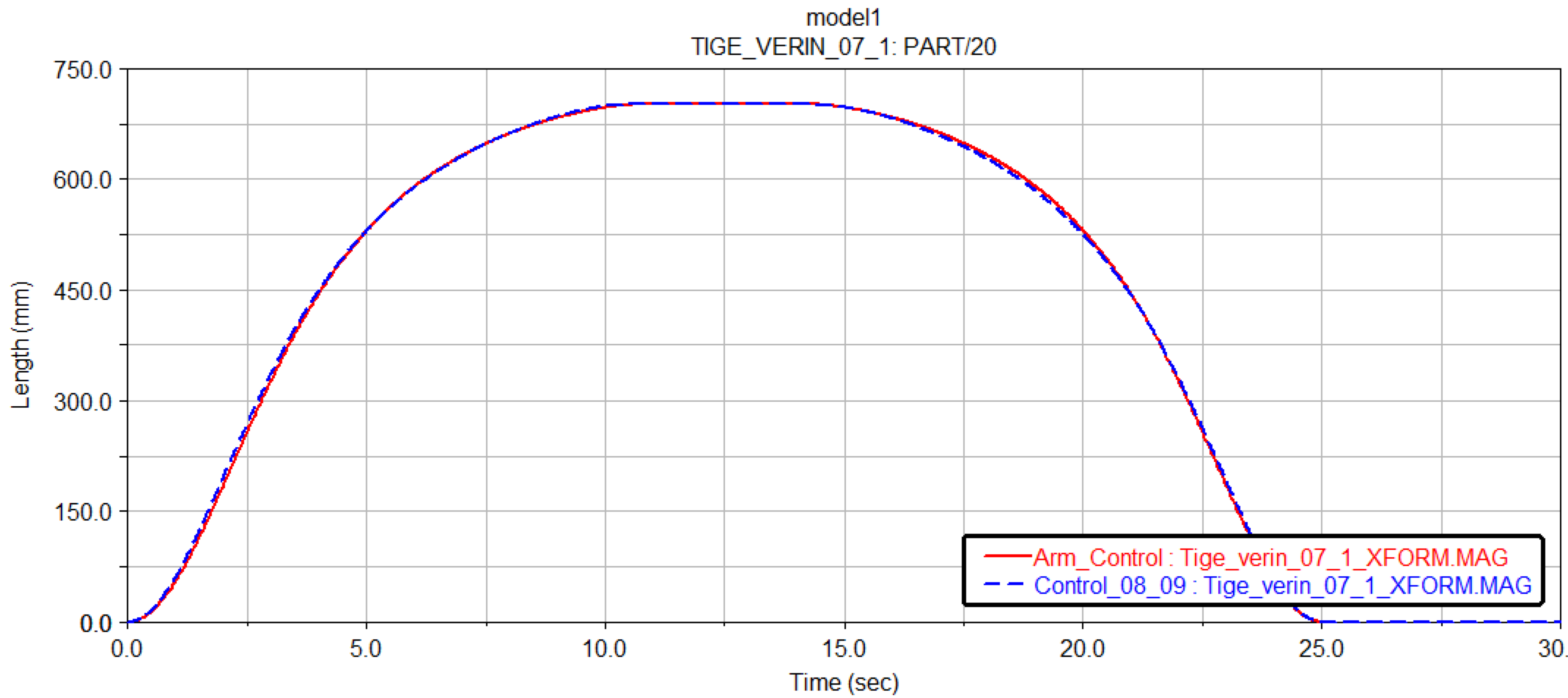
Q5. Is this way of controlling the landing gear a correct solution? If it is not, could you explain why?

When the landing gear is commanded using joint 07-06, although the curve appears relatively normal and the parameters seem consistent, the simulation shows that the landing gear does not fully retract into the bay. A small portion, particularly around the wheels, remains outside, preventing the doors from closing properly. This limitation makes the joint unsuitable for control purposes. Even if the curve appears correct, the actual behaviour does not align with expectations. This is likely due to estimation errors that cannot be corrected at our current level of expertise. This further demonstrates that the joint is restrictive and cannot be reliably controlled.

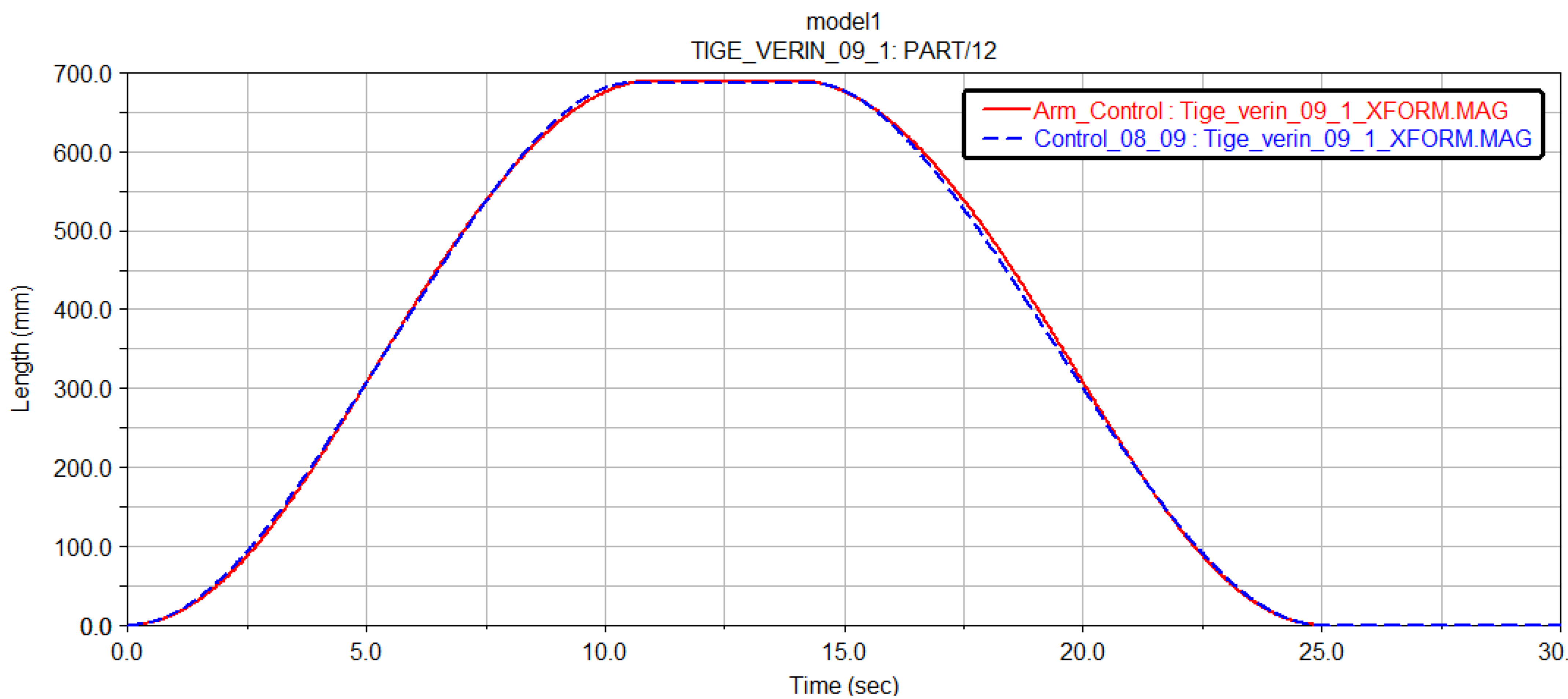
Q6. Plot the angle evolution of the arm 01 for the two solutions (on the same plot).



Q7. Plot the 06-07 actuator displacement for the two solutions (on the same plot).



Q8. Plot the 08-09 actuator displacement for the two solutions (on the same plot).



The selected solution to control the landing gear retraction and extension is the **08-09** actuator control. To allow the retraction, oil under pressure is sent into the cylinder of the **08-09** actuator. The actuator cylinder has a diameter of 60 mm.

Q9. Determine the minimum hydraulic pressure required for the retraction of the landing gear.

The hydraulic pressure :P

The force: F

The cross-sectional area: A

P=F/A

09-08 Fmag_min=1.1118 N

P=391. 52116Pa

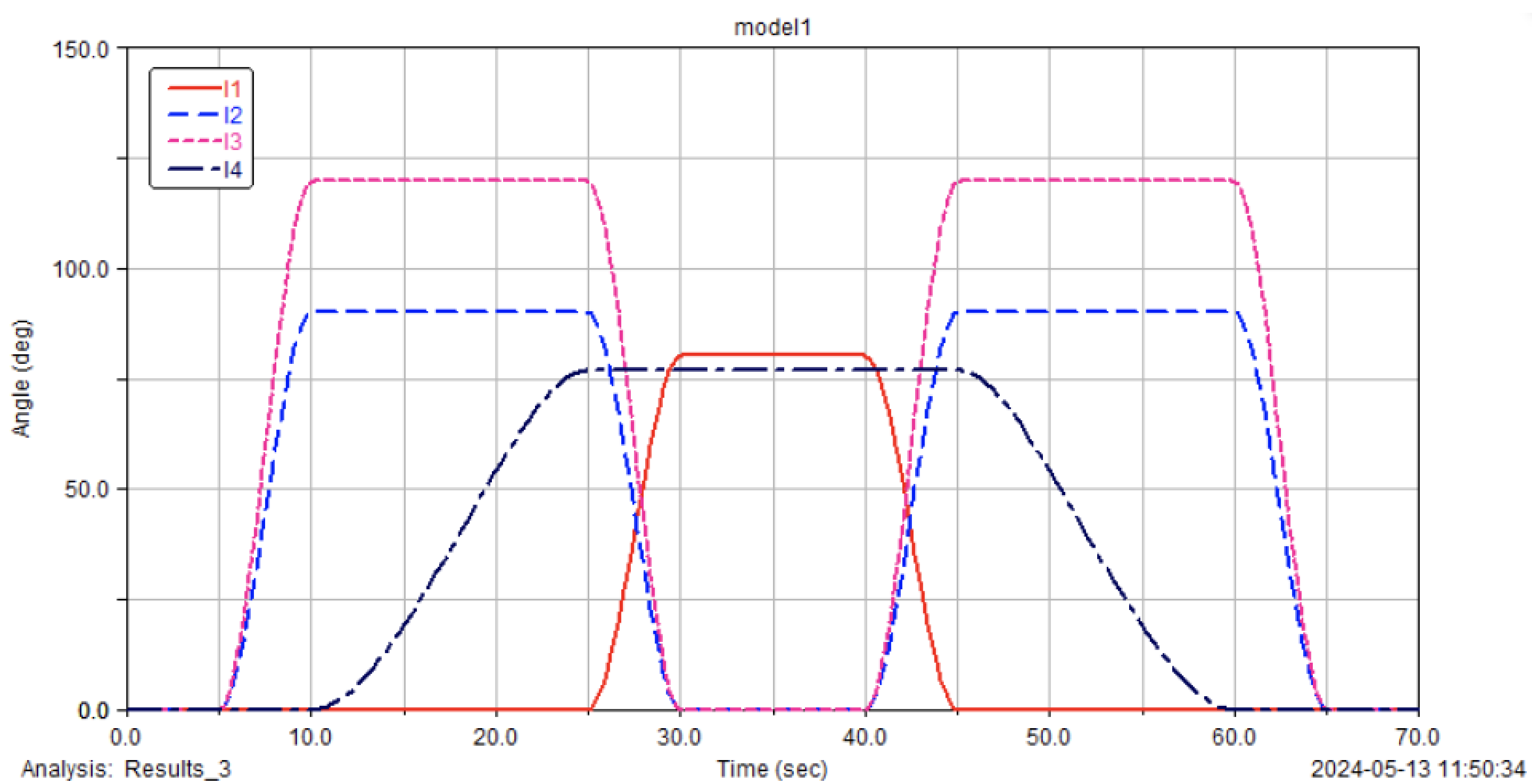
Now, let’s study the opening and closing sequences of the three hatches.

The following chronogram is illustrating the time evolution of different angle controls of the three hatches and of the arm **01**.

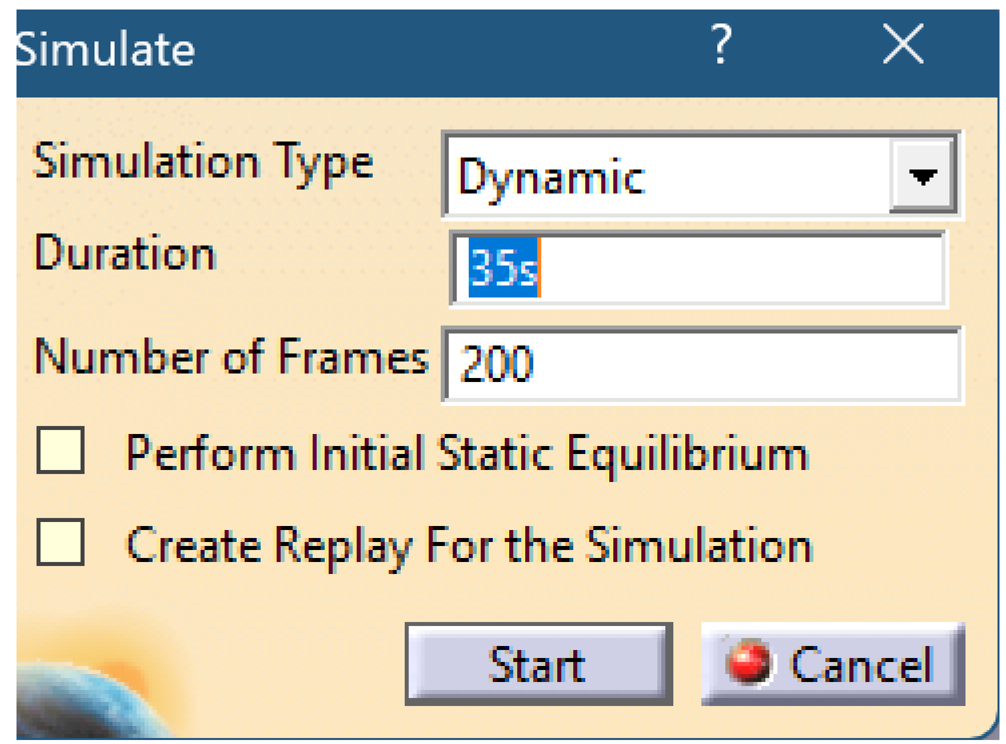
Create the missing kinematic joints between the **Frame** and the three hatches **10**, **11** and **12**. Respectively name them ’10-Frame’, ’11-Frame’ and ’12-Frame’.

We have Done the Simulation run for 35 sec, frame 500

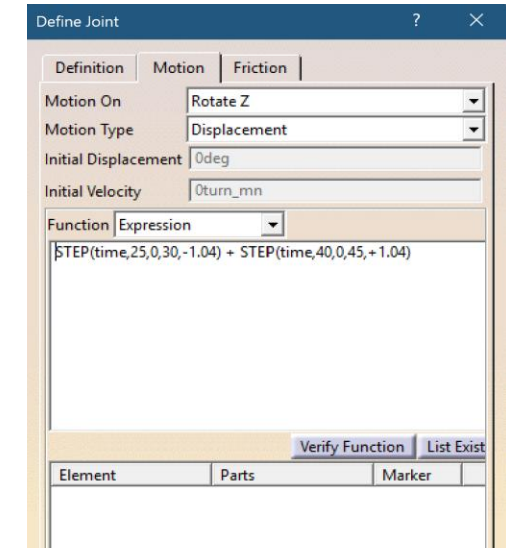
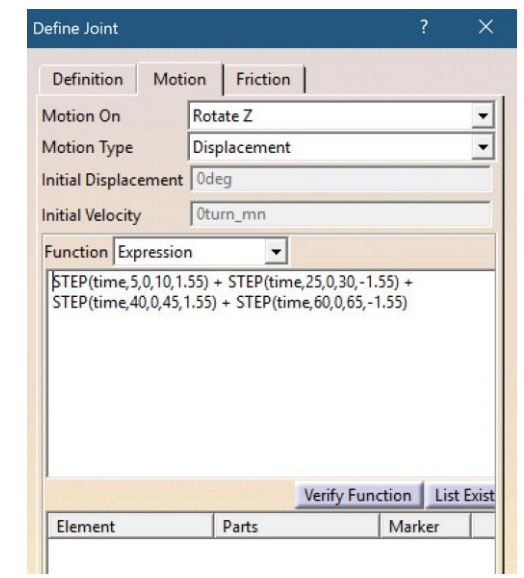
Q10. Match the kinematic joint controls (01-Frame, 10-Frame, 11-Frame and 12-Frame) to the kinematic joints illustrated in the diagram (L1, L2, L3 and L4).

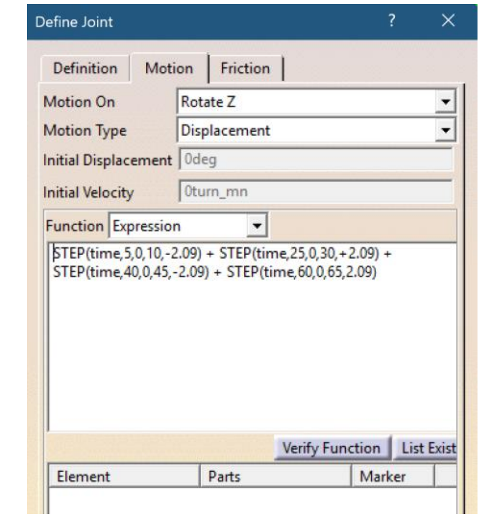
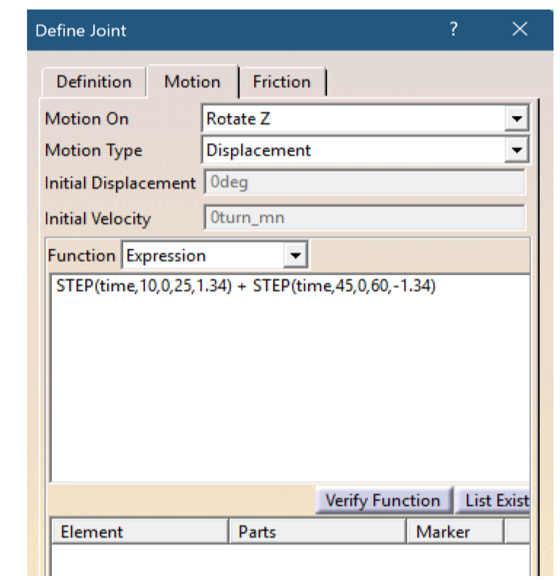


We ran the simulation for 35 frame 200 and the retraction happen properly the hatches open and close for this part correctly.



For Questions 10 to 13 Please refer to the table below

Curves	Controllers	STEP Functions
L1	12-Frame	
L2	10-Frame	

L3	11-Frame	
L4	01-Frame	

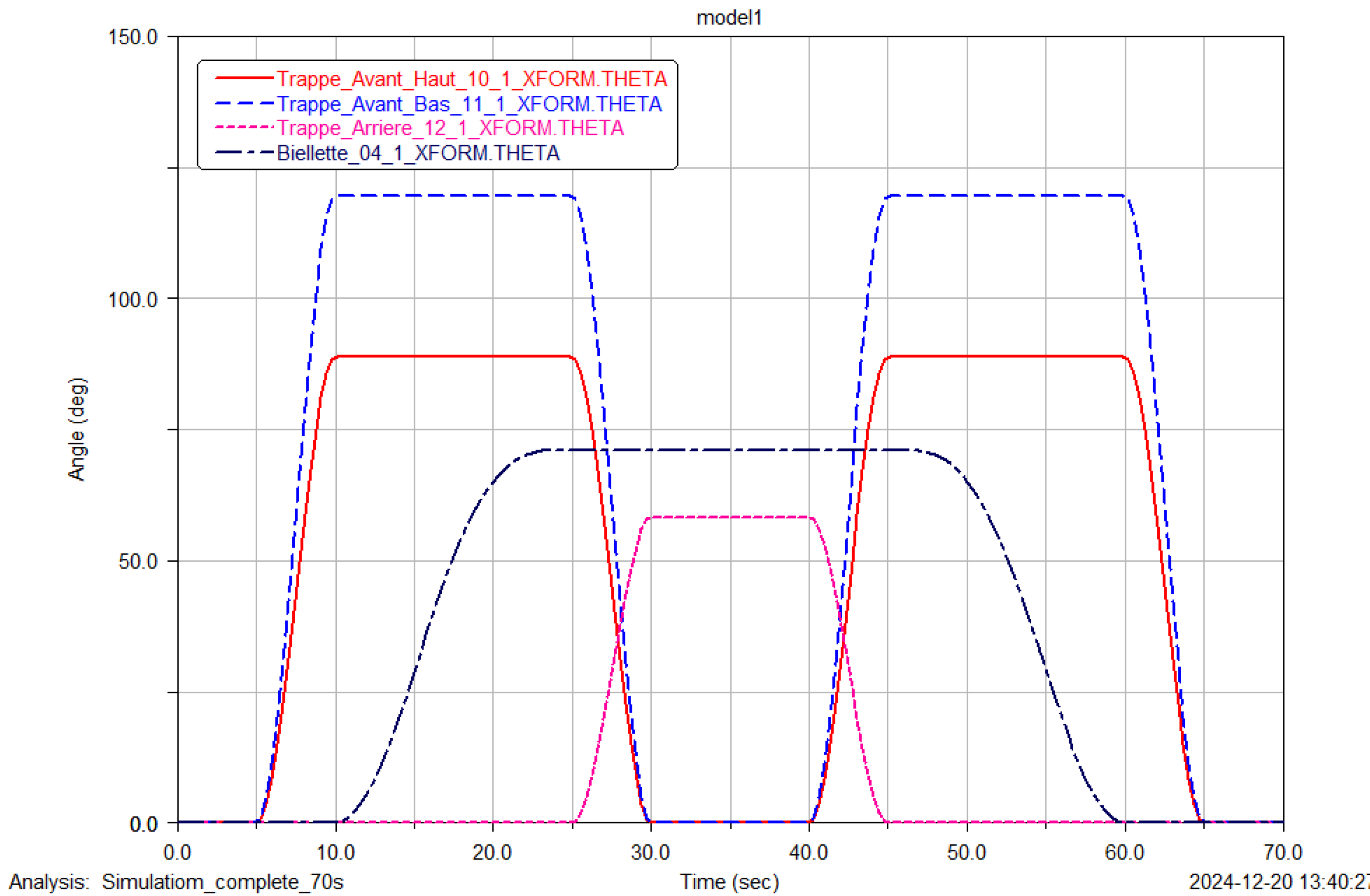
I didn’t encounter any issues when matching the curves with their corresponding controllers, as I relied on graph analysis. I observed the length variations and plotted the movement curves of the joints and motions with controller 08-09 activated, I estimated the displacement length of the three hatches, which gave me an approximate idea of the angles.

Knowing that curve L4 corresponded to controller 01, as we studied earlier, there were only three curves left to assign, which was done easily. The only issue we encountered after the assignment was with controllers 12 and 10. The *step* function for these controllers had to be reversed because the hatches were opening and closing in the wrong directions.

Another adjustment was made to controller 12. On the curve, the angle was 83°, but this did not match the actual landing gear behaviour. The correct angle for the hatches to close properly is 60° (1.02 radians). The 83° angle caused the hatches to overclose, going too deep and leaving a small gap. I gradually reduced the angle from 83° to 60° to achieve a clean and proper closure of the hatches.

Step 11. Run a simulation of 70 s

Q14. Plot the time evolution of the angle of the three hatches and arm 01 to get a similar chronogram as illustrated previously.



Indeed, the billet 04-01 undergoes the same rotational motion as the 01-frame arm. Therefore, plotting the motion of the arm is equivalent to plotting the motion of the billet, which in turn reflects the motion of the arm. This is evident from the graph, as it shows exactly the same curve for both the arm and the billet. This approach turned out to be much simpler than creating an angle measurement. So, I proceeded this way.

Q15. What is the maximum angle for each kinematic joint control to avoid clashes between the landing gear and the hatches.

II. Landing test

Q16. Determine the stiffness $k1$ **of the spring for it to be compressed of** 110 mm **when the fighter is stabilized on the ground, the time of impact is** 0.054 s**.**

Initial spring length = 600 mm

Compression = 110 mm

Time of impact = 0.054 s

Forces acting on the spring

The Recall force of the spring and the weight of the fighter.

P=m·g

F=K1. Δx

According to PFS: P+F=0

M=5000 Kg is the mass of the fighter,

g=9.81 m/s2 is the acceleration due to gravity.

Stiffness relationship

The stiffness k1 of the spring relates to the force and compression Δx\Delta xΔx:

k1=P/(X-X0)

Δx=(X-X0) =490 mm=4.9 m

K1=mg/ Δx

K1= 10010.204 N/m

Q17. What is the damping coefficient $c1$**?**

$$C_1 = \zeta \cdot 2\sqrt{km}$$

I choose a damping ratio of 0.7: ζ

C1=9904.54 N.m/s

Conclusion

This project was a great experience that helped me learn about the landing gear system of a fighter jet. I worked on understanding how the landing gear moves during retraction and extension, as well as how it handles the impact when landing. I completed most of the steps and gained a good understanding of how the system works.

However, I faced a problem in the second part of the project. Even though I followed all the steps to set up the simulation, the software kept closing when I tried to run it. Unfortunately, I started this part at the last minute, so I didn't have enough time to fix the issue.

Overall, I enjoyed this project and learned a lot about dynamic systems and simulations. It was fun and rewarding to work on, and it taught me the importance of managing my time better in the future.