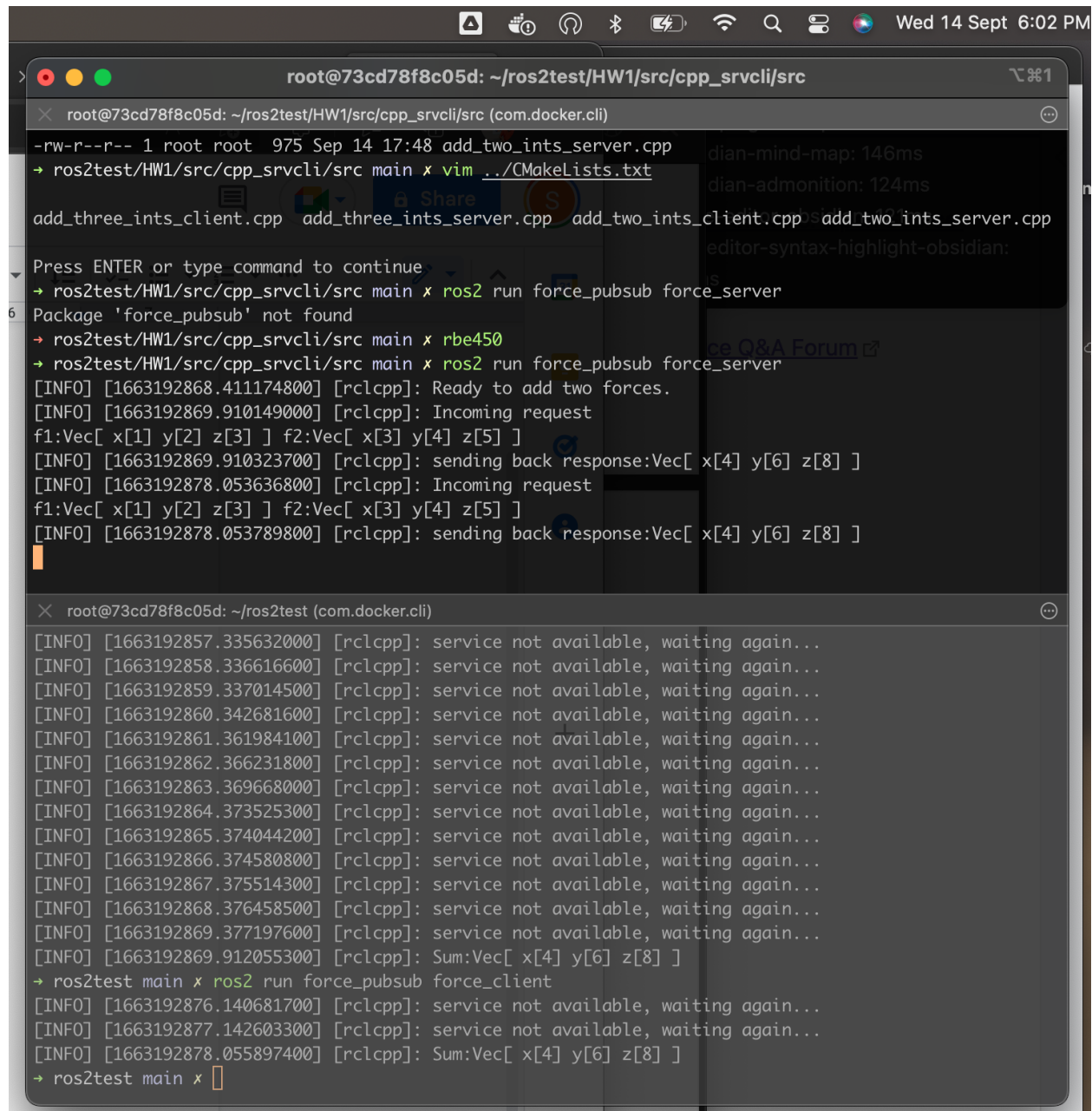


Part 2 -- ROS Assignment

GitHub link for all the codes can be found [here](#)

Screen shot of the server and client pair. Top terminal is server and bottom terminal is client



The screenshot shows two terminal windows on a macOS system. The top window is titled 'root@73cd78f8c05d: ~/ros2test/HW1/src/cpp_srvcli/src' and shows the execution of a ROS2 server. The bottom window is titled 'root@73cd78f8c05d: ~/ros2test (com.docker.cli)' and shows the execution of a ROS2 client. Both windows show the output of the 'ros2 run' command, including package names, timestamps, and the results of the service calls.

```
root@73cd78f8c05d: ~/ros2test/HW1/src/cpp_srvcli/src
root@73cd78f8c05d: ~/ros2test/HW1/src/cpp_srvcli/src (com.docker.cli)
-rw-r--r-- 1 root root 975 Sep 14 17:48 add_two_ints_server.cpp
→ ros2test/HW1/src/cpp_srvcli/src main x vim ../CMakeLists.txt
add_three_ints_client.cpp add_three_ints_server.cpp add_two_ints_client.cpp add_two_ints_server.cpp
Press ENTER or type command to continue
→ ros2test/HW1/src/cpp_srvcli/src main x ros2 run force_pubsub force_server
Package 'force_pubsub' not found
→ ros2test/HW1/src/cpp_srvcli/src main x rbe450
→ ros2test/HW1/src/cpp_srvcli/src main x ros2 run force_pubsub force_server
[INFO] [1663192868.411174800] [rclcpp]: Ready to add two forces.
[INFO] [1663192869.910149000] [rclcpp]: Incoming request
f1:Vec[ x[1] y[2] z[3] ] f2:Vec[ x[3] y[4] z[5] ]
[INFO] [1663192869.910323700] [rclcpp]: sending back response:Vec[ x[4] y[6] z[8] ]
[INFO] [1663192878.053636800] [rclcpp]: Incoming request
f1:Vec[ x[1] y[2] z[3] ] f2:Vec[ x[3] y[4] z[5] ]
[INFO] [1663192878.053789800] [rclcpp]: sending back response:Vec[ x[4] y[6] z[8] ]

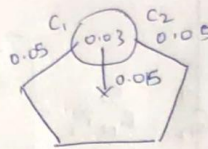
root@73cd78f8c05d: ~/ros2test (com.docker.cli)
[INFO] [1663192857.335632000] [rclcpp]: service not available, waiting again...
[INFO] [1663192858.336616600] [rclcpp]: service not available, waiting again...
[INFO] [1663192859.337014500] [rclcpp]: service not available, waiting again...
[INFO] [1663192860.342681600] [rclcpp]: service not available, waiting again...
[INFO] [1663192861.361984100] [rclcpp]: service not available, waiting again...
[INFO] [1663192862.366231800] [rclcpp]: service not available, waiting again...
[INFO] [1663192863.369668000] [rclcpp]: service not available, waiting again...
[INFO] [1663192864.373525300] [rclcpp]: service not available, waiting again...
[INFO] [1663192865.374044200] [rclcpp]: service not available, waiting again...
[INFO] [1663192866.374580800] [rclcpp]: service not available, waiting again...
[INFO] [1663192867.375514300] [rclcpp]: service not available, waiting again...
[INFO] [1663192868.376458500] [rclcpp]: service not available, waiting again...
[INFO] [1663192869.377197600] [rclcpp]: service not available, waiting again...
[INFO] [1663192869.912055300] [rclcpp]: Sum:Vec[ x[4] y[6] z[8] ]
→ ros2test main x ros2 run force_pubsub force_client
[INFO] [1663192876.140681700] [rclcpp]: service not available, waiting again...
[INFO] [1663192877.142603300] [rclcpp]: service not available, waiting again...
[INFO] [1663192878.055897400] [rclcpp]: Sum:Vec[ x[4] y[6] z[8] ]
→ ros2test main x
```

Part I

Assuming that object has to be moved by a distance of 0.015m

HW1.

(A) Grasp Matrix



$$\sum_{i=1}^N C_i = R_N^T P_i \sum_{i=1}^N$$

$$G_2^T = R_N^T P_2 R_N^T \Rightarrow \begin{pmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{pmatrix} \Rightarrow \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

$$G_1^T = R_N^T P_1 R_N^T \Rightarrow \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \Rightarrow \begin{pmatrix} +1 & 0 & 0 \\ 0 & +1 & 0 \\ 0 & 0 & +1 \end{pmatrix}$$

$$P_1 = (C_1 - 0) = \frac{0.03}{2} \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \Rightarrow S(C_1 - 0) = \begin{pmatrix} 0 & -\frac{0.03}{2} & 0 \\ \frac{0.03}{2} & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$P_2 = (C_2 - 0) = \frac{0.03}{2} \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \Rightarrow S(C_2 - 0) = \begin{pmatrix} 0 & -\frac{0.03}{2} & 0 \\ \frac{0.03}{2} & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$P_1 = \begin{pmatrix} 1 & 0 & 0 & 0 & -\frac{0.03}{2} & 0 \\ 0 & 1 & 0 & \frac{0.03}{2} & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \quad P_2 = \begin{pmatrix} 1 & 0 & 0 & 0 & -\frac{0.03}{2} & 0 \\ 0 & 1 & 0 & \frac{0.03}{2} & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$G_1^T = R_N^T P_1 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 & -\frac{0.03}{2} & 0 \\ 0 & 1 & 0 & \frac{0.03}{2} & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$G_2^T = R_N P_2 = \begin{bmatrix} -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 & -0.003 & 0 \\ 0 & 1 & 0 & 0 & 0.003 & 0 \\ 0 & 0 & 1 & 0 & 0.003 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$G_1^T = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & -0.003 \\ 0 & 1 & 0 & 0 & 0.003 & 0 \\ 0 & 0 & 1 & 0 & 0.003 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} G_2^T = \begin{bmatrix} -1 & 0 & 0 & 0 & 0.003 & 0 \\ 0 & 1 & 0 & 0 & 0.003 & 0 \\ 0 & 0 & 1 & 0 & 0.003 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 \end{bmatrix}$$

$$G_0^T = \begin{bmatrix} 1 & 0 & 0 & 0 & -0.003 & 0 \\ 0 & 1 & 0 & 0 & 0.003 & 0 \\ 0 & 0 & 1 & 0 & 0.003 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 & 0.003 & 0 \\ 0 & 1 & 0 & 0 & 0.003 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 \end{bmatrix}$$

(B) Desired velocity = $-\frac{0.015}{2} \hat{j} = 75 \times 10^{-4} \hat{j} = \bar{v}$

desired angular velocity = 0

$$\bar{\xi}_0^N = \begin{pmatrix} 0 \\ -75 \times 10^{-4} \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

$$\bar{\xi}_{c_1}^{C_1} = G_1^T \bar{\xi}_0^N \Rightarrow \bar{\xi}_{c_1}^{C_1} = \begin{pmatrix} 0 \\ -75 \times 10^{-4} \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \bar{\xi}_{c_2}^{C_2} = \begin{pmatrix} 0 \\ 75 \times 10^{-4} \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$