Homework 1 & 2

Answer to the following questions, showing all the drawings and intermediate math work by uploading a PDF file containing the work. Feel free to add comments in the text box. You can assume that each question consider the robot starting point as the initial one, i.e., it does not depend on the answer to previous questions.
This assignment is **individual** (i.e., no group work, the work should be your own).
You can obtain a total of 5 points for this assignment.

Q1:
Assume that you have the mobile robot modeled as a differential drive robot, in a rectangular warehouse (10m x 10m). The warehouse has a flat floor and no obstacles. Its walls are aligned with respect to the compass points (north and east). The 'map' reference frame is attached to the bottom left corner of the warehouse, at position 0, 0, 0, and with roll, pitch, yaw of 0, 0, 0. The robot is turned on starting at the center of the warehouse, pointing towards the North.

Submit a document file in PDF format where you should:
1. Draw the reference frames of the 'map', 'odom', and 'base_link', specifying the conventions followed (see for the conventions https://www.ros.org/reps/rep-0105.html#coordinate-frames), and
2. write the homogeneous transformation matrices between 'map' and 'odom' , and between 'odom' and 'base_link'.

Q2:
Assume a distance of **0.35m** between the wheels. Given a velocity on the left wheel of **0.45pi m/s** and velocity on the right wheel of **0.55pi m/s** for **0.5 seconds**, write in a document what the new pose of the robot in the map reference frame is.
Please show also the ICC in the map reference frame and update the homogeneous transformation matrix between 'odom' and 'base_link'.

Q3:
Suppose a sonar sensor is on top of the robot at 30 degrees pitch rotation and translated of 0.2m along the z-axis of 'base_link'.

Write:
1. what the expected measurement from the sensor is, given that the floor is flat.
2. such a point in the 'map reference frame' by applying the appropriate transformation.

Q4:
An operator gives the robot a goal destination in the map reference frame, 4.8m, 4.8m, -pi/4 (x, y, yaw) -- the rest (z, roll, pitch) are 0.

Write such a point in the 'base_link' reference frame.

Q5:
Solve the inverse kinematics to get to the goal destination specified in **Q4**, writing the velocities that need to be sent to the wheels and the time duration, with a rotation-translation-rotation motion, and write the updated the homogeneous transformation matrix between 'odom' and 'base_link'.