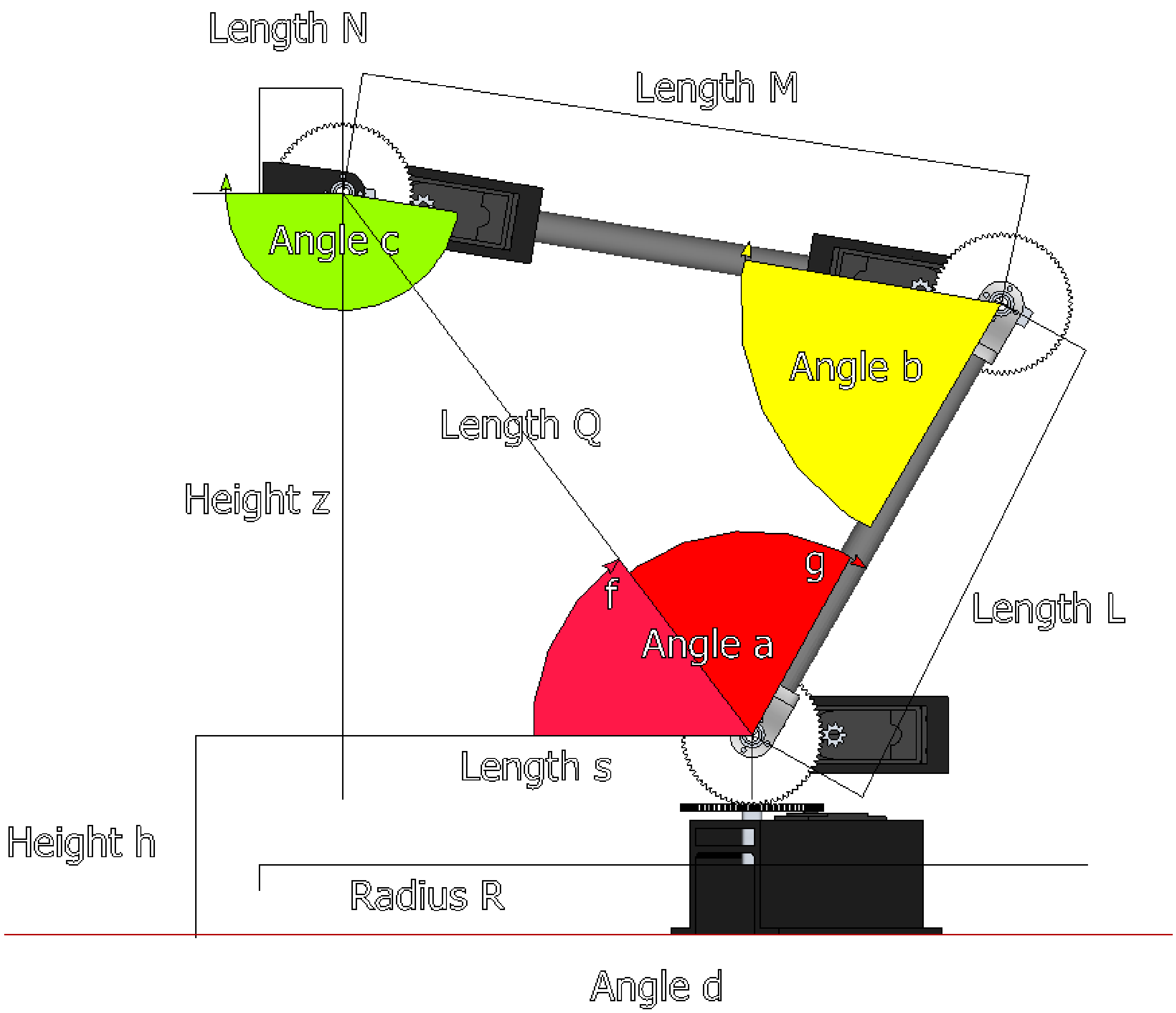
Important note: During assembly, try to avoid rotating the servo motors manually as it creates back EMF and added wear on the motors.

Once the assembly is complete, the servos need to be positioned properly. Since there is an additional 5:1 gearing after the servo, each joint rotation angle is not automatically centered. Ensuring the joint is centered is currently a manual / visual process. We suggest configuring it as follows:



Note that the "zero" degree angles for the elbow and wrist would cause the arm to try to reach a position it is mechanically incapable of reaching. Therefore when configuring the arm, we suggest using two different angles (such as 90 degrees and 180 degrees) and the associated servo pulses to develop a linear equation relating the servo pulse to the angle.

Calculating Angles Based on x, y, z

This is just one way of calculating the joint angles based on coordinate (x,y,z) of the end of the gripper. Note that the equations need to be calculated in RADIANS (not degrees) and then converted back to degrees. We also suggest including constraints to ensure the given point can be reached by the arm.

L is the length of the shoulder axis to the elbow axis
M is the length of the elbow axis to the wrist axis
N is the length of the wrist axis to the end of the gripper (or the desired point)

R = (x^2) + (y^2)
Represents the radius from the axis of rotation of the base to x,y

s = R – N
Since the arm has four degrees of freedom, there are infinite solutions possible for the arm to reach point (x,y,z). We will therefore introduce an artificial constraint and keep the gripper at a specific angle to the horizontal, and calculate for a new coordinate (x_1, y_1, z_1) of the wrist axis.

Q = [(s^2) + (z^2)]^(1/2)
This is the distance between the shoulder axis and the wrist axis

f = atan2(z, s)
This is the angle between the horizontal and the line Q. The atan function would return two angles whereas the atan2 function determines the correct angle based on the x and y coordinate. The actual height is h + z which can be taken into account when inputting

g = acos[((L^2)+(Q^2)–(M^2)) / (2*L*Q)]
This is the angle between line Q and link L using the law of cosines.

Use the equations above to find angles a, b, c and d:

a = f + g
This is angle ‘a’ above.

b = acos[((M^2)+(L^2)–(Q^2)) / (2*L*M)]
This is angle ‘b’ above using the law of cosines.

c = –b – a + 2*pi
This is angle ‘c’. Angle c is kept horizontal to the (x,y) plane.

d = math.atan2(x, y)
This is the angle ‘d’ of the base.