**Project**

The LEGO NXT-based 2-link planar manipulator has an offset. This offset is the space between 2 LEGO holes (8 mm). If one does not account for this offset, the end-effector will not be accurately positioned. The following sketch more accurately reflects what the 2-link manipulator looks like



One observes that $u=8 mm$ introduces an offset and hence impact the inverse kinematics. One can derive that:

$μ-θ\_{2}=atan2\left(\pm \left\{1-\left(\frac{x\_{p}^{3}+y\_{p}^{2}-l^{'}\_{1}^{3}-l\_{2}^{2}}{2l'\_{1}l\_{2}}\right)^{2}\right\}^{1/2}, \frac{x\_{p}^{3}+y\_{p}^{2}-l^{'}\_{1}^{3}-l\_{2}^{2}}{2l'\_{1}l\_{2}}\right)$

(1)

and

(2)

$$θ\_{1}=atan2\left(y\_{p},x\_{p}\right)-atan2\left(\frac{l\_{2}\sin(θ\_{2}+u)}{l\_{1}+l\_{2}\cos(θ\_{2})}\right)$$

Write your report that documents the following:

1. Use the algebraic method to derive Equations (1) and (2) which are the inverse kinematics that account for the offset $u$
2. The offset $u$ can be viewed as a (fixed) link. Treat the manipulator above as a 3-link one. Sketch the DH reference frames, give a table of DH link parameters. Calculate the tool transformation matrix. Show that the last column of the tool transformation matrix has Equations (1) and (2).
3. Write and video record (provide YouTube) link demonstrating your results that account for the offset.
4. Define a path (e.g. straight-line, rectangle, curvilinear line). Write and video record (provide YouTube) link demonstrating the end-effector moving along this path.