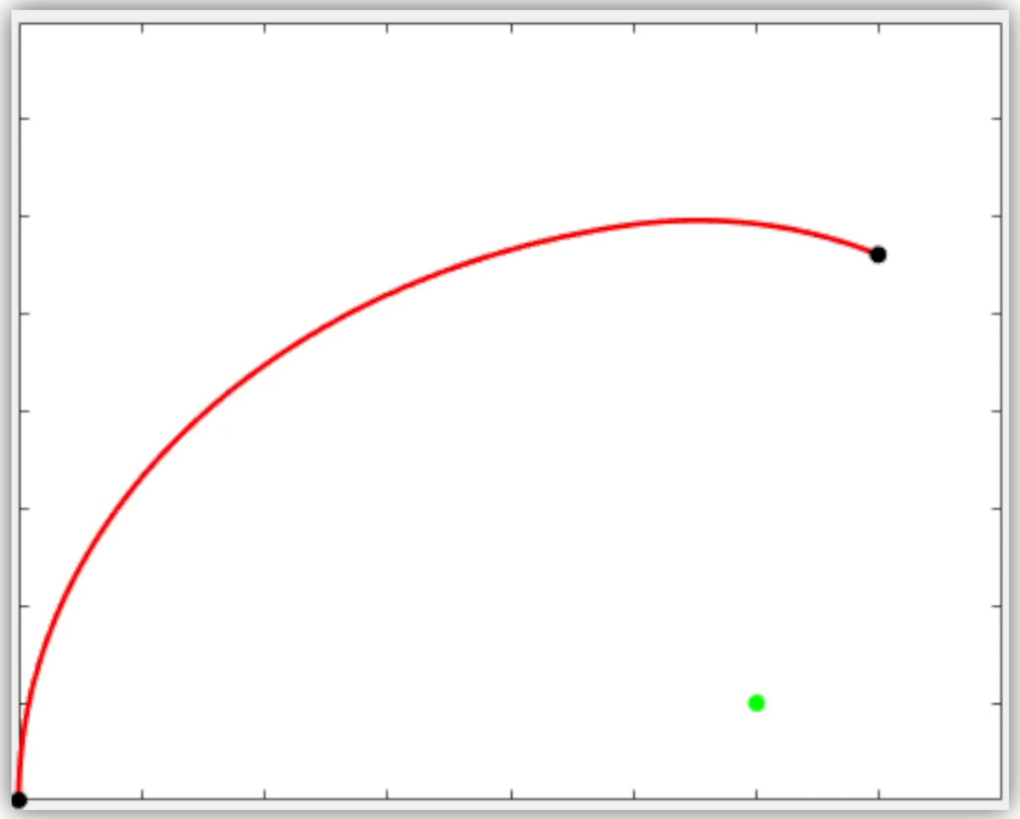
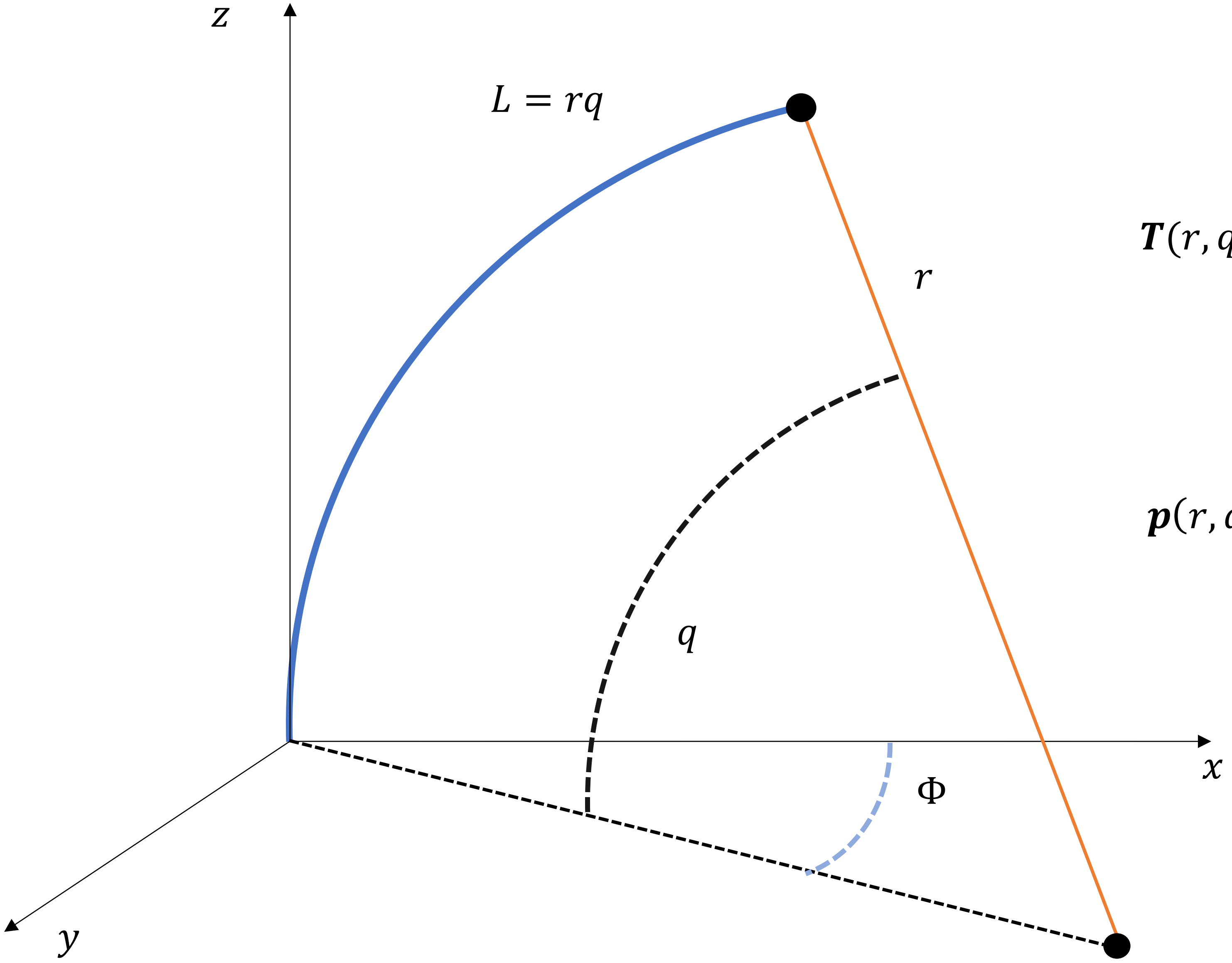
Lab Activity

Implement a model-based *kinematic* controller

- PCC assumption
- 2-segments
- The soft robot must reach a target location in the space



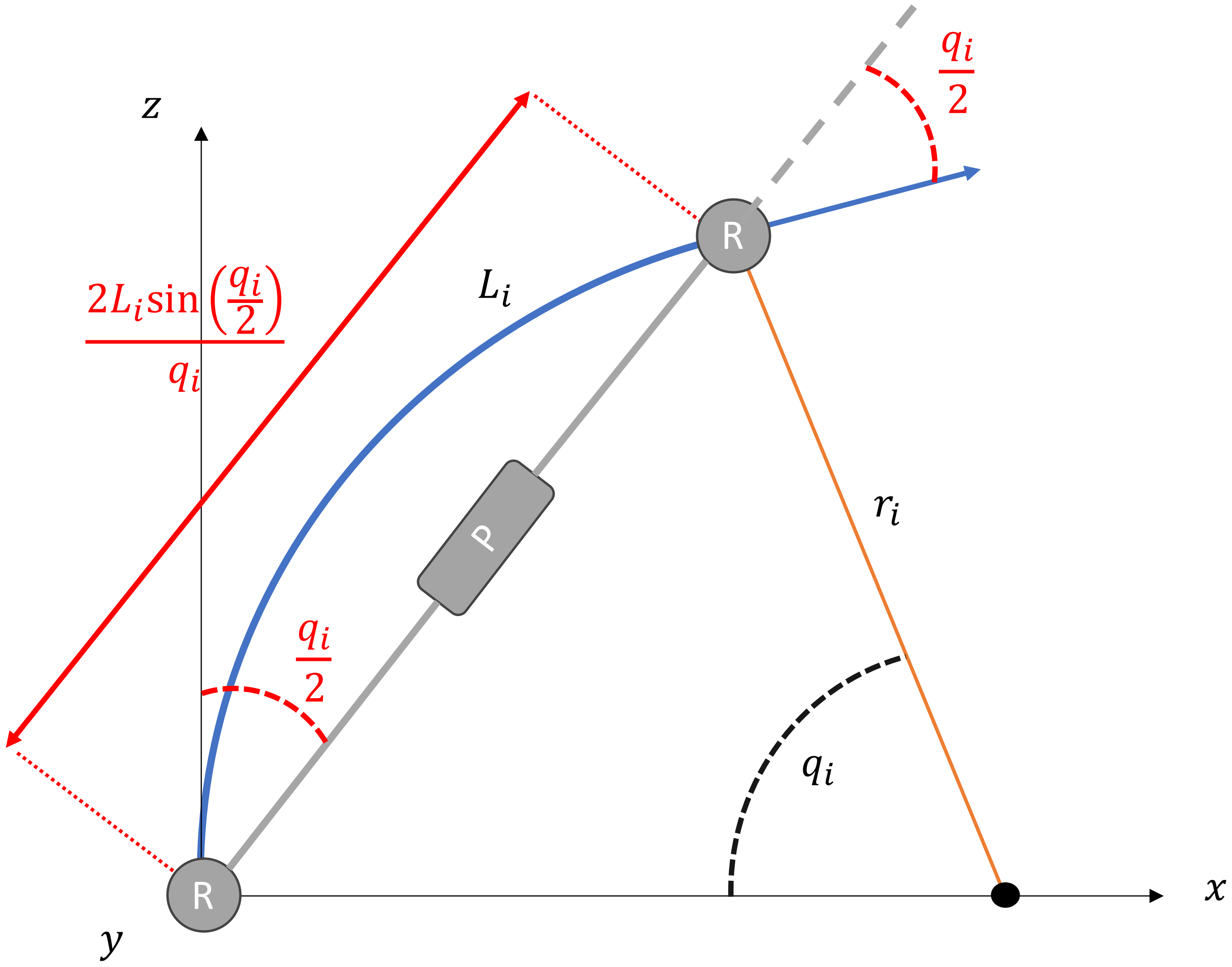
PCC Model

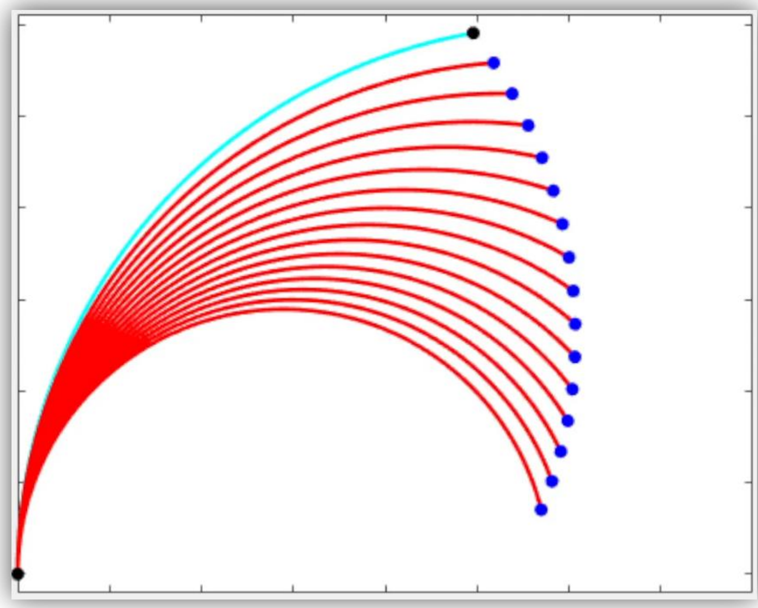


$$\boldsymbol{T}(r,q,\Phi) = \underbrace{\begin{bmatrix} \boldsymbol{R_z}(\Phi) & \boldsymbol{0} \\ \boldsymbol{0} & 1 \end{bmatrix}}_{\text{Rotation}} \underbrace{\begin{bmatrix} \boldsymbol{R_y}(q) & \boldsymbol{p}(r,q) \\ \boldsymbol{0} & 1 \end{bmatrix}}_{\text{In-plane transformation}}$$

$$\boldsymbol{p}(r,q) = [r[1-\cos(q)], 0, r\sin(q)]^T$$

Augmented Model





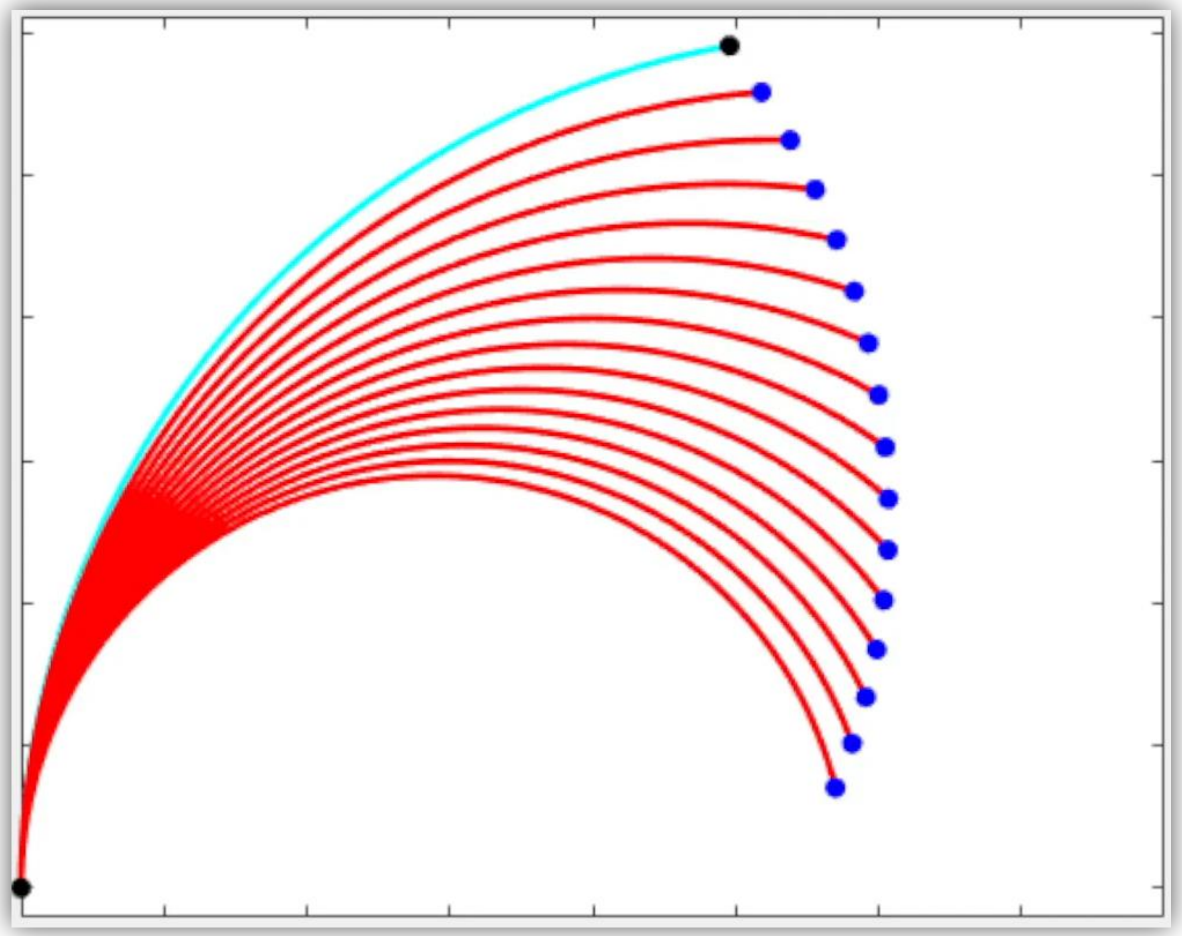
$$m_i(q_i) = \begin{bmatrix} \frac{q_i}{2} \\ \frac{2}{q_i} L_i \sin\left(\frac{q_i}{2}\right) \\ \frac{q_i}{2} \end{bmatrix} \begin{array}{l} \rightarrow 1^{st}\ \textbf{R}\ \text{joint} \\ \rightarrow \textbf{P}\ \text{joint} \\ \rightarrow 2^{st}\ \textbf{R}\ \text{joint} \end{array}$$

$$m(\boldsymbol{q}) = [\, m(q_1) \quad \dots \quad m(q_N)]$$

Ref: Della Santina et al. 2020

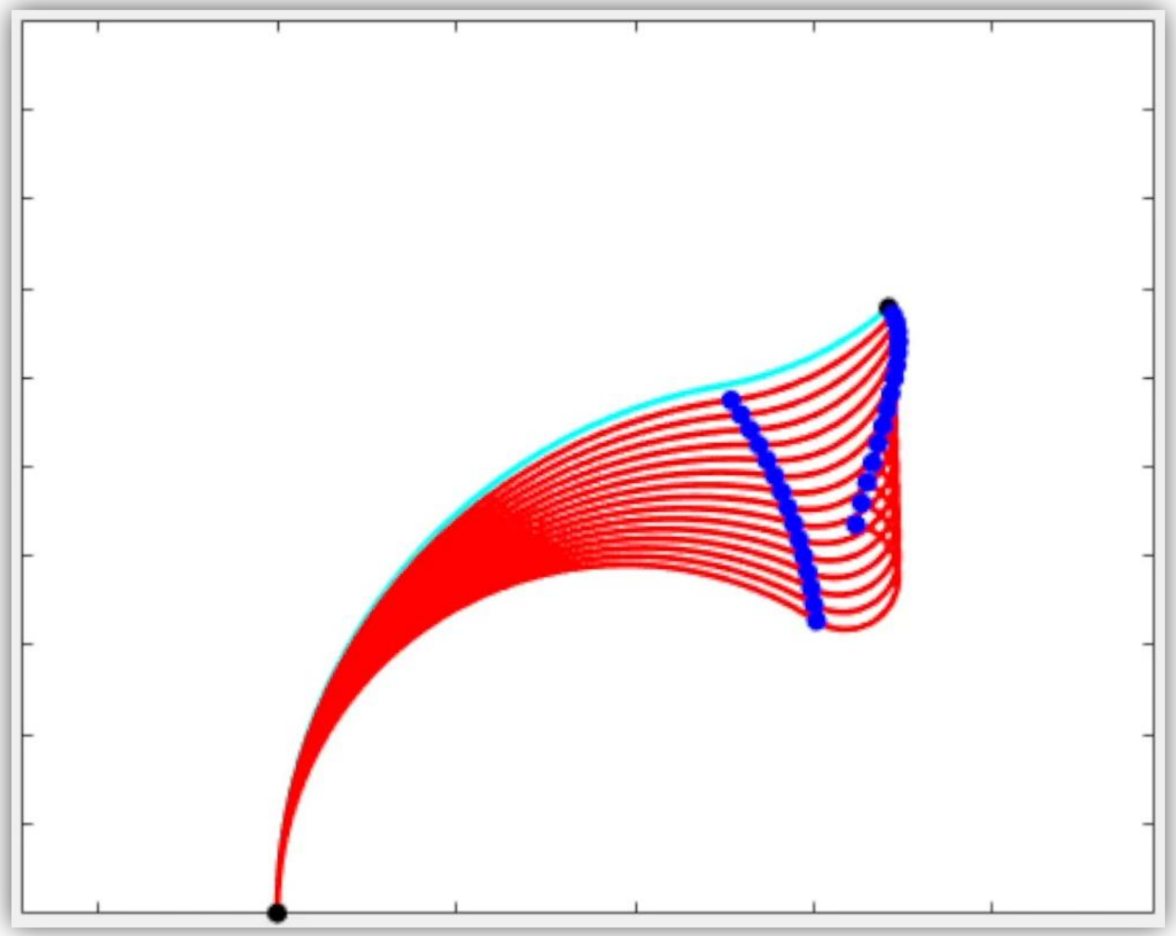
Exercise 1

- Write the mapping $\mathrm{m}(\boldsymbol{q})$ for a 1-segment robot
- Draw the arc by increasing $\boldsymbol{q}$ of steps $\Delta\boldsymbol{q} = 0.1$
- Compute the position $\boldsymbol{x_{ee}}$ (i.e. the tip of the arc) from the mapping $\mathrm{m}(\boldsymbol{q})$



Exercise 2

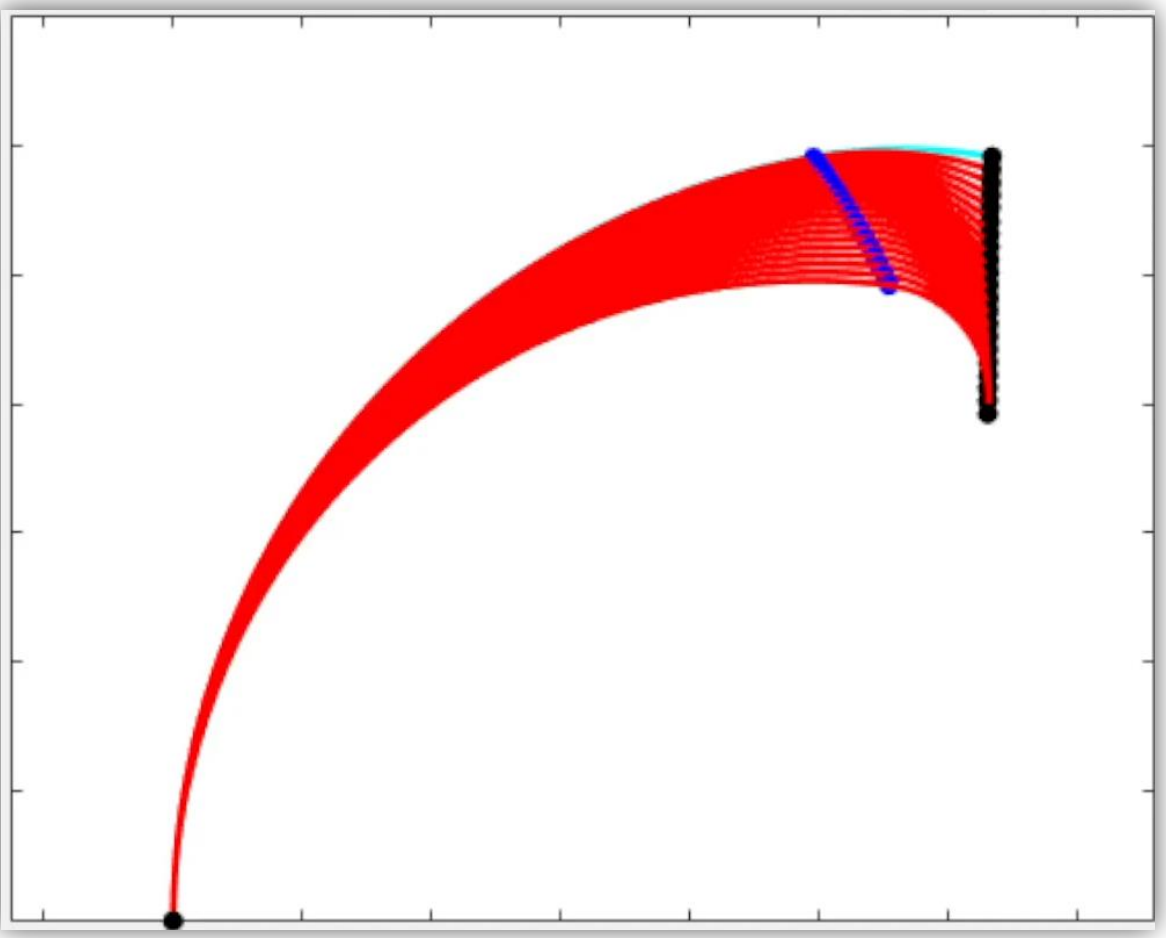
- Write the mapping $\mathrm{m}(\boldsymbol{q})$ for a 2-segment robot
- Draw the arc by increasing $\boldsymbol{q}$ of steps $\Delta\boldsymbol{q} = [0.05, 0.2]^T$
- Compute the position $\boldsymbol{x_{ee}}$ (i.e. the tip of the arc) from the mapping $\mathrm{m}(\boldsymbol{q})$



Exercise 3

- Given the Jacobian of the robot $\mathbf{J}(\boldsymbol{q})$ write a Cartesian velocity controller

- Test the controller by applying a reference velocity $\dot{\boldsymbol{x}} = [0, -0.05]^T$



Exercise 4

- Given a target position in the space $\boldsymbol{x} = [0.3, 0.05]^T$, write a Cartesian controller
- The controller should minimize the distance between $\boldsymbol{x}$ and $\boldsymbol{x}_{\boldsymbol{ee}}$