Flexible rod

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Consider the flexible rod depicted in (A):

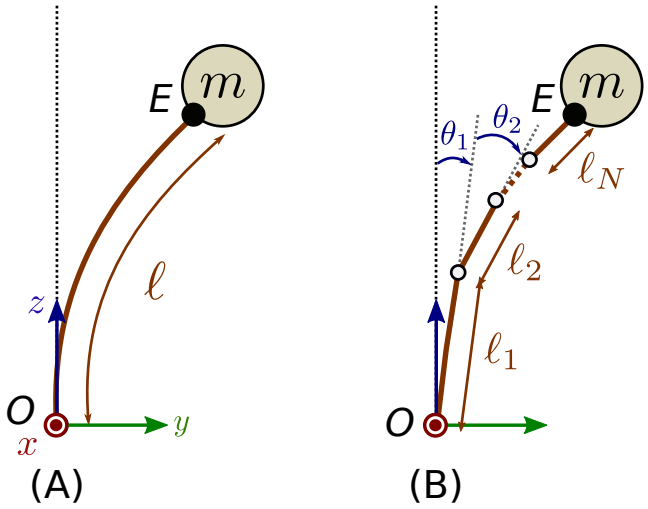

Figure 1: Flexible rod and its discretization.

We discretize it into N segments, as shown in (B), with ℓ_i the length of segment i and θ_i the angle it makes with its parent segment (or the vertical for θ_1).

Our goal is to compute the position ${}_W p_E$ of the end-effector point E with in the inertial frame W whose origin is the point O.

- **Question 1:** *Attach a frame to each link, and write down the transform $T_{i,i+1}$ from link $i+1$ to its parent link i.*
- **Question 2:** *Calculate the transform $T_{W,N}$ from the last link N to the inertial frame W, and then p_E.*

Let's consider the case where all segments have the same length $\ell_i = \frac{\ell}{N}$ and the rod has uniform curvature, so that all relative orientations θ_i are equal to $\frac{\Theta}{N}$.

- **Question 3:** *Calculate in closed form the expression of p_E when the number of segments $N \to \infty$.*
- **Question 4:** *What value of Θ maximizes the distance between E and O? What value minimizes it?*

