Homework - RR robot arm

A two-link planar robot arm is shown in the figure. The length of the links are $L_1 = 1$ m and $L_2 = 1$ m. The masses of the rigid links are $m_1 = 1$ kg and $m_2 = 1$ kg. The gravitational acceleration is $g = 9.81$ m/s^2.
The generalized coordinates are $q_1(t)$ and $q_2(t)$.

The initial conditions, at $t = 0$ s, are $q_1(0) = -\pi/18$ rad, $\dot{q}_1(0) = 0$ rad/s, $q_2(0) = \pi/6$ rad, and $\dot{q}_2(0) = 0$ rad/s.

The robot arm can be brought from an initial state of rest to a final state of rest in such a way that q_1 and q_2 have the specified values $q_{1f} = \pi/6$ rad and $q_{2f} = \pi/3$ rad.

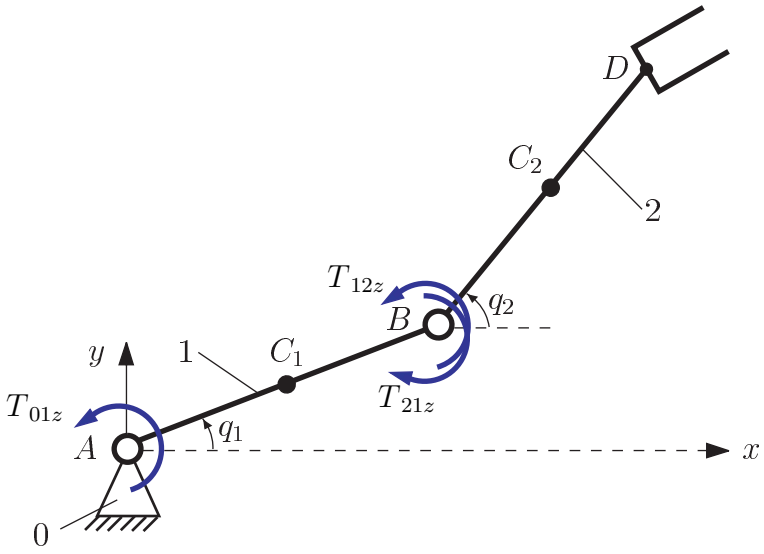
The set of contact forces transmitted from 0 to 1 can be replaced with a couple of torque $\mathbf{T}_{01} = T_{01z}\,\mathbf{k}$ applied to 1 at A. Similarly, the set of contact forces transmitted from 1 to 2 can be replaced with a couple of torque $\mathbf{T}_{12} = T_{12z}\,\mathbf{k}$ applied to 2 at B. The law of action and reaction then guarantees that the set of contact forces transmitted from 1 to 2 is equivalent to a couple of torque $-\mathbf{T}_{12}$ to 1 at B.

A desired motion of the robot arm has been specified for a time interval $0 \le t \le T_p = 15$ s. The generalized coordinates can be established explicitly

$$q_r(t) = q_r(0) + \frac{q_r(T_p) - q_r(0)}{T_p}\left[t - \frac{T_p}{2\,\pi}\sin\left(\frac{2\,\pi\,t}{T_p}\right)\right], \quad r = 1, 2.$$

with $q_r(T_p) = q_{rf}$.

Find $T_{01z}(t)$ and $T_{12z}(t)$ for $0 \le t \le T_p = 15$ s.



Figure