ME751-Assignment 8

Problem 1. [SimEngine3D track, MATLAB/Python/C] For the simple pendulum of Problem 1 in the previous assignment (Assignment 7), perform a dynamic analysis using a Quasi-Newton approach. The gravitational acceleration (not shown in the picture) is assumed to act in the opposite direction of the global z axis; its magnitude is $g = 9.81$ (in SI units). Use a BDF method of order 2, seeded at the beginning of the simulation by a BDF method of order 1. The simulation should run for $t \in [0, 10]$.

a) Provide a plot that displays the value of the torque as a function of time

b) In your report also include the following **7 plots**. The first three plots will display the x, y, and z coordinates of Body 1's point O' expressed in the G-RF as a function of time. The next three plots will show the angular velocity of Body 1 in the G-RF as a function of time. The last plot will display the 2-norm of the violation of the velocity constraint equations for the revolute joint between Body 1 and ground (you'll have five scalar velocity constraint equations, you need to compute the 2-norm of this vector; i.e., the violation of the velocity kinematic constraint equation)

c) Include in your report the amount of time it took your `simEngine3D` solver to finish the simulation. Indicate the step size you used to generate the results.

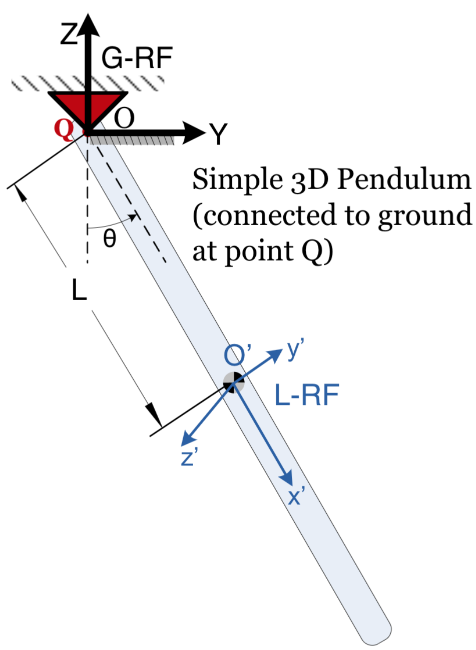

Figure 1: Pendulum with revolute joint.

Problem 2. [SimEngine3D track, MATLAB/Python/C] This problem builds on the simple pendulum of the previous problem. The schematic of the mechanism is shown in Figure 2.

You will have to carry out a Dynamics Analysis for the mechanism for 10 seconds of its evolution using a BDF method of order 1 in conjunction with a Quasi-Newton method for solving the resulting discretization nonlinear system of equations. For initial conditions consider the first pendulum (Body

1) to be horizontal; i.e. according to Figure 2, $\theta = \pi/2$, while the second pendulum (Body 2) is hanging down, making a $\pi/2$ angle with the first pendulum. Both bodies have zero velocity at time $t = 0$. The bodies move in a gravitational field.

a) In your report include **13 plots**. The first three plots will display the x, y, and z coordinates of Body 1's point O' expressed in the G-RF as a function of time. The next three plots will show the angular velocity of Body 1 in the G-RF as a function of time. The next six plots will display the same information for Body 2's point O'. The last plot will display the 2-norm of the violation of the velocity constraint equations for the revolute joint between Body 1 and Body 2 (you'll have five scalar velocity constraint equations, you need to compute the 2-norm of this vector; i.e., the violation of the velocity kinematic constraint equation)

b) Include in your report the amount of time it took your `simEngine3D` solver to finish the simulation. Indicate the step size you used to generate the results (make sure the results are converged and not garbage)

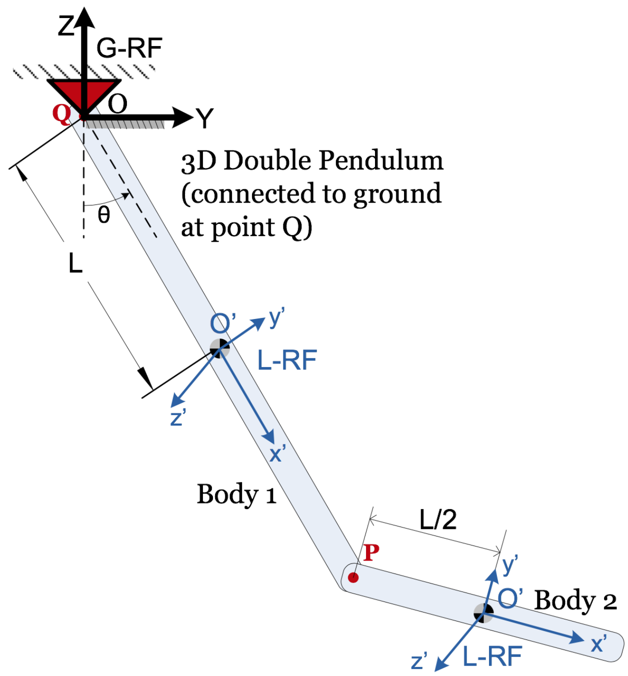

Figure 2: 3D Double Pendulum.