Assignment 6: Due March 4.

Problem 1. Prove that for $\mathbf{\Phi}^{\mathbf{p}}$, the right-hand side of the acceleration equation assumes the form

$$\gamma^{\mathbf{p}} = \begin{bmatrix} -2\dot{\mathbf{p}}_1^T \dot{\mathbf{p}}_1 \\ \cdots \\ -2\dot{\mathbf{p}}_{nb}^T \dot{\mathbf{p}}_{nb} \end{bmatrix}$$

Problem 2. Say you solve for $\dot{\mathbf{r}}$ and $\bar{\omega}$, and recover for each body i the time derivative of the Euler Parameters as $\dot{\mathbf{p}}_i = \frac{1}{2}\mathbf{G}_i^T \bar{\omega}_i$. Prove that this value of $\dot{\mathbf{p}}_i$ is consistent, in that it satisfies the constraint obtained when you take a time derivative of the Euler Parameter normalization constraint.

Problem 3. Use the Newton-Raphson method to solve for a solution α of the equation

$$f(x) = x^6 - x - 1 = 0$$

As an initial guess, use $x^{(0)} = 2$. Provide a table that on the first column has the iteration counter k, next column contains $x^{(k)}$, then $f(x^{(k)})$, then $x^{(k)} - \alpha$, and finally $x^{(k+1)} - x^{(k)}$. Note that the solution that you should find is $\alpha = 1.13472413840152$. Explain what happens if you start with $x^{(0)} = -1$.

Problem 4. Derive the expression of $\bar{\mathbf{\Pi}}_i^{DP2}$ and $\bar{\mathbf{\Pi}}_j^{DP2}$, and $\bar{\mathbf{\Pi}}_i^{D}$ and $\bar{\mathbf{\Pi}}_j^{D}$.

Problem 5. Implement two (at least) MATLAB functions that provide all the computational kinematics quantities that are associated with the basic GCons Φ^{DP1} and Φ^{CD}. Specifically, the MATLAB functions should be able to return any or all of the following quantities: the value of the expression of the constraint, the right-hand side of the velocity equation ν, the right-hand side of the acceleration equation γ, the expressions of $\bar{\Pi}$ and Π, the expression of the partial derivatives $\Phi_{\mathbf{r}}$ and $\Phi_{\mathbf{p}}$. Since you don't need all these quantities all the time, you should devise a mechanism (using maybe flags) to instruct the subroutine what quantities are actually needed.

Note that you will need an input file that contains information that a user would provide to specify the attributes of your GCons. Since the user specifies the *value* of the attributes, but not the format and order in which these attributes are to be provided in an input file, you will also have to think about the format in which you will have the user provide the required attributes. In conclusion, think about how you want the model attributes to be provided to you, and then generate a file with extension "me751.mdl" (from model), that actually specifies the attributes for your 3D Simulation Engine. As an example, take a look at the ADAMS adm file ("adm" stands for ADAMS Database Model, doesn't make too much sense) that is uploaded on the class website. If you want to push it to an extreme, you can actually start using adm files as your model definition files[1].

Finally, note that you will have to have another MATLAB file called "simEngine3D.m", which when executed by the TA is expected to generate all the Kinematics quantities listed above by reading the attributes and data specified in a "me751.mdl" file that you also have to generate.

[1] This would qualify you for the Pre-Processing Category winner.