MATLAB Assignment 8

When working on this assignment you might want to take a look at MATLAB code that was developed by students who took ME451 in previous years. The students back then did not come up with identical solutions. Take a look at their solutions and develop your own.
2010: http://sbel.wisc.edu/Courses/ME451/2010/SimEngine2D/index.htm
2011: http://sbel.wisc.edu/Courses/ME451/2011/SimEngine2D/index.htm

Turning in your assignment: place all your files in a directory called "lastName_Matlab_08", zip that directory, and upload the resulting file "lastName_Matlab_08.zip" in the appropriate Dropbox Folder at Learn@UW.

Problem 1. Implement MATLAB code that opens a file, called model.adm, and parses the JSON data below in order to read in the information required to fully define force elements of type *PointForce* and *Torque*. All force elements in an ADM model (in JSON format) are expected to be collected into an array which is the "value" for a key named `forces` (much like we did for the set of constraints in a model).

```
"forces":
[
  {
    "name": "point_force",
    "id": 1,
    "type": "PointForce",
    "body1": 1,
    "sP1": [1.4, 0.2],
    "frame": "GRF",
    "funX": "sin(t + pi/3)",
    "funY": "-9.81"
  },
  {
     "name": "my_torque",
     "id": 2,
     "type": "Torque",
     "body1": 5,
     "fun": "10*t"
  }
]
```

Notes:

- All force elements have the following common attributes: a name and id (assumed to be unique within the model) and a type.

- In addition to the above, a *PointForce* element specifies the body on which the force acts, the point P on that body where the force is applied (expressed in the body's LRF), two functions (either of which can be a constant) which define the x- and y-component of the force, and finally the `frame` property which can be one of "LRF" or "GRF" indicating that the two force components are specified in the body Local Reference Frame or in the Global Reference Frame.
- If a *PointForce* element specifies the force in the LRF, then before using this force and convert it to the corresponding generalized force, you must first re-express it in the GRF (that is, you must pre-multiply it by the body's rotation matrix $A(\phi)$).
- In addition to the properties common to all force elements, a *Torque* element specifies the body it acts on and the expression for a function describing the time evolution of the applied torque.

Problem 2. Consider the double pendulum in Fig.6.5.2 (page 233). Notice that a horizontal force is specified on the second body. Assume that this concentrated force always stays horizontal, and its magnitude is always 5 N. Although not shown, assume that a positive torque $n = 2.5\ N \cdot m$ is applied to body 1. Additionally, take $l_1 = l_2 = 1$, and $m_1 = m_2 = 2$ (all units SI). The mass moment of inertia should be computed based on information in Table 6.1.1 (page 208). The bodies are moving in a gravitational field with $g = -9.81 m/s^2$. Use Cartesian generalized coordinates and the centroidal reference frames as shown in the textbook.

1. How many degrees of freedom does this mechanism have?
2. What is the dimension of the Lagrange Multiplier vector λ for this mechanism?
3. Determine a set of initial positions and initial velocities for this mechanism. Assume that the two pendulums are horizontal and stretched out to your right (along the global OX axis), and that the bodies are at rest.
4. Using the initial conditions determined above, generate a pair of files doublePend.acf and doublePend.adm that you would use to carry out Dynamics analysis of this mechanism in simEngine2D. The length of the simulation should be 5 seconds, the time step $\Delta t = 0.0005$, while the number of output steps is 100.
5. For the initial configuration of the mechanism, report on the forum the content of the matrix that you use in order to compute the acceleration $\ddot{\mathbf{q}}$ and Lagrange Multipliers λ (the coefficient matrix in Eq.6.3.18 at page 224).
6. For the initial configuration of the mechanism, report on the forum the content of the right-hand size that you use in order to compute the acceleration $\ddot{\mathbf{q}}$ and Lagrange Multipliers λ; i.e., the vector $\begin{bmatrix} \mathbf{Q}^A \\ \gamma \end{bmatrix}$ in Eq.6.3.18 at page 224. Remember that there is a $\mathbf{Q}_1^A \in \mathbb{R}^3$ acting on body 1, $\mathbf{Q}_2^A \in \mathbb{R}^3$ acting on body 2, and $\mathbf{Q}^A = \begin{bmatrix} \mathbf{Q}_1^A \\ \mathbf{Q}_2^A \end{bmatrix} \in \mathbb{R}^6$.