# MAE 511 HW Set 1

## Due Date: Sept 5, 2018 by 3pm

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1. Use Mathematica™ to show that Equations 3.5-1 and Equations 3.5-2 from the Thomson book are equivalent. Hint: To accomplish this, use the matrix form of these equations as found in Equations 3.5-3 and 3.5-4.

Solution Procedure:

- RHS1 is the ω matrix.
- rotmat is the rotation matrix in equation 3.5-3
- angvel is the matrix containing time derivatives of the angles as calculated from equation 3.5-3
- rotmat2 is the rotation matrix in equation 3.5-4
- angvel2 is the matrix containing time derivatives of the angles as calculated from equation 3.5-4

After defining the matrices as above, the inverse of rotmat is taken (In[55] in code). This matrix is same as rotmat2, as shown in line In[56].

Similarly, angvel and angvel2 are calculated from the equations 3.5-3 and 3.5-4 respectively and compared. These matrices are also equal as shown in line In[53].

Each step of the code is explained using comments.

2. Use matlab™ to simulate (using ode45) the equations of motion for a double pendulum found on page 78 of the Meirovitch book. Set $m_1 = 2$ kg, $m_2 = 3$ kg, $L_1 = 0.8$ meters, $L_2 = 0.6$ meters, and use initial conditions: $\theta_1(0) = 0.2$ radians, $\theta_2(0) = 0.3$ radians, $d\theta_1/dt(0) = 0.4$ radians/second, $d\theta_2/dt(0) = 0.5$ radians/second. Simulate the equations for 20 seconds and plot $\theta_1(t)$ and $\theta_2(t)$ versus time on separate plots.

Solution Procedure:

1. The equations are not in standard form, so the first step is to separate the expressions of $\ddot{\Theta}_1$ and $\ddot{\Theta}_2$. For this purpose, the equations from the book are written in the $\bar{A}.\vec{x} = \bar{B}$ form.
2. The above equation is solved using the "linsolve" function of Matlab, with elements of $\vec{x}$ being $\ddot{\Theta}_1$ and $\ddot{\Theta}_2$, $\bar{A}$ containing their coefficients and $\bar{B}$ containing the rest of the expression. The solution to this is a pair of 2nd order non-linear differential equations.
3. To convert this 2nd order differential equation into a 1st order (to use "ode45" function), state space method is used.
   $x1 = \theta_1$
   $x2 = \dot{\theta}_1$
   $y1 = \theta_2$
   $y2 = \dot{\theta}_2$
4. So, 4 equations are obtained of the following form:

$\bar{x} = [x1 \quad x2 \quad y1 \quad y2]^T$

5. A function is called that simultaneously assigns values to the $\bar{x}$ (as written above) and LHS expressions that would be input into the "ode45" function.
6. The time span put in is [0 20] and the initial conditions are [0.2 0.3 0.4 0.5]. This completes all the inputs into the ode45 function and the output is $\bar{x}$ at different values of t.
7. The values of $\theta_1$ and $\theta_2$ corresponds to x1 and y2 respectively, and a plot is of their values v/s time is made.