

## MeEn 537 Homework #1

1. Work the following problems from chapter 2 in your textbook (for some of these, the answers are very simple and the goal instead is understanding and experience with the toolbox):
  - (a) 2
  - (b) 4
  - (c) 5
  - (d) 10
  - (e) 16
  - (f) 20
2. Consider the following sequences of rotation and write the matrix product that will give the resulting rotation matrix (don't perform the operation, just write the correct form):
  - (a) rotate by  $\phi$  in the x-axis,  $\theta$  in the z-axis, then  $\psi$  in the y-axis all in the current frame.
  - (b) rotate by  $\phi$  in the x-axis,  $\theta$  in the z-axis, then  $\psi$  in the y-axis all in the fixed world frame.
3. If coordinate frame  $o_1$  is obtained by rotating coordinate frame  $o_0$  by  $\frac{\pi}{2}$  about x-axis followed by a rotation of  $\frac{\pi}{2}$  about the y-axis, find the rotation matrix  $R$  that represents the composite transformation. Sketch the initial and final frames.
4. Suppose three coordinate frames ( $o_0, o_1, o_2$ ) are given, and that

$$R_2^1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{2} & -\frac{\sqrt{3}}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{1}{2} \end{bmatrix}, \quad R_3^1 = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

Find the matrix  $R_3^2$

5. Compute the rotation matrix given by the following product: (you may use the toolbox and symbolic variables to do this)
 
$$R_{x,\theta} R_{y,\phi} R_{z,\pi} R_{y,-\phi} R_{x,-\theta}$$
6. Let  $R$  represent a rotation of  $90^\circ$  about  $y_0$  followed by a rotation of  $45^\circ$  about  $z_1$ . Find the equivalent axis/angle to represent  $R$ . Sketch the initial and final frames and the equivalent axis vector  $k$ . Also find the equivalent quaternion representation.
7. Find the rotation matrix corresponding to the Euler angles  $\phi = \frac{\pi}{2}$ ,  $\theta = 0$ , and  $\psi = \frac{\pi}{4}$ . What is the direction of the new x-axis relative to the base frame?