- 1. Write the matrix product that will give the resulting rotation matrix for the following sequence of rotations. Do not perform multiplication.
 - (a) Rotate by α about fixed x-axis
 - (b) Rotate by β about current z-axis
 - (c) Rotate by γ about fixed y-axis
 - (d) Rotate by ϕ about current y-axis
 - (e) Rotate by ψ about fixed z-axis
 - (f) Rotate by θ about current x-axis
- 2. Coordinate frame {3} is obtained from frame {0} by the following sequence of rotations:
 - (a) -90° about the fixed z-axis
 - (b) 90° about the current y-axis
 - (c) -90° about the fixed x-axis.

Find the resulting rotation matrix C_3^0 and sketch frames $\{0\}$ and $\{3\}$ relative to each other.

3. Consider the rotation matrix

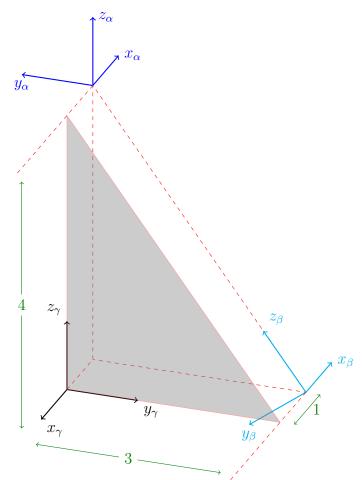
$$C_b^a = \begin{bmatrix} -0.3536 & 0.1268 & -0.9268 \\ 0.6124 & 0.7803 & -0.1268 \\ 0.7071 & -0.6124 & -0.3536 \end{bmatrix}.$$

- (a) What are the Roll-Pitch-Yaw angles (ϕ, θ, ψ) that describe the orientation of frame $\{b\}$ relative to $\{a\}$?
- (b) What is the angle-axis (θ, \vec{k}) that describes the orientation of frame $\{b\}$ relative to $\{a\}$?
- (c) What is the quaternion \bar{q} that describes the orientation of frame $\{b\}$ relative to $\{a\}$?
- (d) Given a velocity as the vector $\vec{v}^a = [-1, 1, -1]^T$ written in terms of frame $\{a\}$, what is the vector \vec{v}^b that describes the same velocity relative to frame $\{b\}$?
- 4. Given the Roll-Pitch-Yaw angles $(\phi, \theta, \psi) = (120^{\circ}, 45^{\circ}, -120^{\circ})$, find the rotation matrix that describes the same orientation.
- 5. Given the angle-axis $(\theta, \vec{k}) = (90^{\circ}, \frac{1}{\sqrt{3}}[1, 1, 1]^{T})$, find the rotation matrix that describes the same orientation.

- 6. Given the quaternion $\bar{q} = [0.5, -0.5, -0.5, -0.5]^T$, find the rotation matrix that describes the same orientation.
- 7. Consider the three coordinate frames $\{\alpha\}$, $\{\beta\}$, and $\{\gamma\}$ shown in the diagram below. Following the notation introduced in class, find the following Cartesian position vectors (denoted by \vec{r}) and rotation/cosine matrices (denoted by C).



- (b) $\vec{r}_{\alpha}^{\gamma}$
- (c) $\vec{r}_{\gamma\beta}^{\gamma}$
- (d) $\vec{r}_{\alpha\gamma}^{\alpha}$
- (e) $\vec{r}_{\gamma\beta}^{\beta}$
- (f) C^{γ}_{α}
- (g) C^{γ}_{β}
- (h) C^{α}_{β}



Due: Tu 02/11/2020