# HW #2: WRITTEN
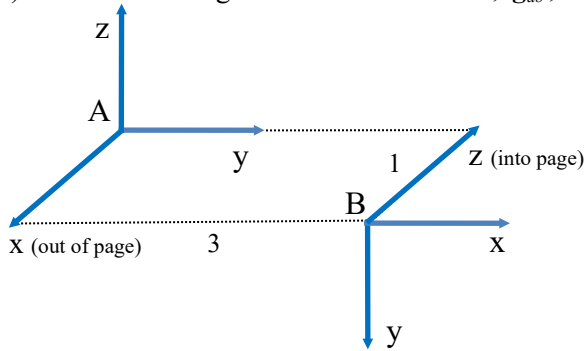
Box answers and show all work in the space provided. Submit at the start of class on the scheduled due date.

1) Find the homogeneous transformation, $\bar{g}_{ab}$, that transforms coordinates of a point from frame B to frame A shown.



2) Assume a rigid body transformation, $g_{ab}$, is defined by the rotation matrix $\mathbf{R}_{ab}$ and the translation $\mathbf{p}_{ab}$ as defined below. Find the homogeneous representation of $g_{ab}$.

$$\mathbf{R}_{ab} = \begin{bmatrix} 0 & 0 & -1 \\ -1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \qquad \mathbf{p}_{ab} = \begin{bmatrix} 2 \\ 1 \\ -1 \end{bmatrix}$$

3) Consider the rigid body transformation given below. Find $\bar{g}_{ab}^{-1}$.

$$\bar{g}_{ab} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4) Consider the rigid body transformation given below. Find $\bar{g}_{ab}^{-1}\bar{g}_{ab}$.

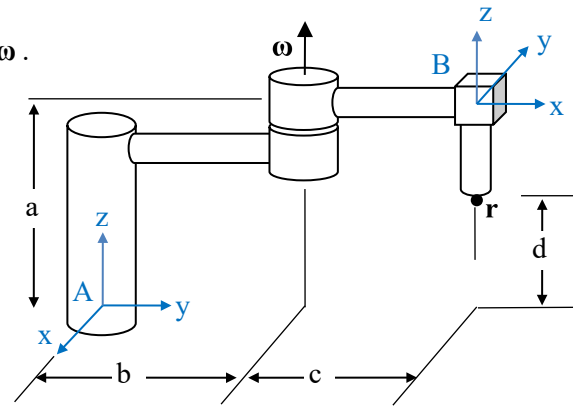$$\bar{g}_{ab} = \begin{bmatrix} 0 & 0 & -1 & 7 \\ 0 & 1 & 0 & 8 \\ 1 & 0 & 0 & 9 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

5) Consider the rigid body transformation $\bar{g}_{ab}$ below that maps points from frame B to frame A. The coordinates of a point $\mathbf{p}$ in the B frame is also given. Find the coordinates of the point in the A frame.

$$\bar{g}_{ab} = \begin{bmatrix} 0 & 1 & 0 & -2 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad \mathbf{p}_b = \begin{bmatrix} 2 \\ 1 \\ -1 \end{bmatrix}$$

For the remaining problems, consider the 1 DOF robot arm shown in the home position. Point **r** is fixed to tool frame B which rotates about axis $\boldsymbol{\omega}$.

6) Find the rotation axis, $\boldsymbol{\omega} \in \mathbb{R}^3$, and a point on the rotation axis, $\mathbf{q} \in \mathbb{R}^3$.

7) Find the twist, $\xi$, for the rotation about the axis $\boldsymbol{\omega}$.

8) Find the wedge ($\hat{\xi}$) version of the twist, $\xi$, from the previous problem.

9) Find the initial position, $\mathbf{r}_a(0)$, of point **r** as viewed from the inertial frame A. Also find the position, $\mathbf{r}_b$, of point **r** as viewed from body frame B.

10) Find the home configuration, $\mathbf{g}_{ab}(0)$, of body frame B with respect to inertial frame A.

11) Give the formula for the rigid body transformation, $\mathbf{g}_{ab}(\theta)$, that maps points fixed to the tool frame B to the inertial frame A as a function of rotation angle $\theta$ about rotation axis $\boldsymbol{\omega}$.