

Practice Set 8

Robotics & Automation
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Using your textbook and what we covered in lecture, try solving the following problems. For some problems you may find it convenient to use Matlab (or another programming language of your choice). The solutions are on the next page.

Problem 1

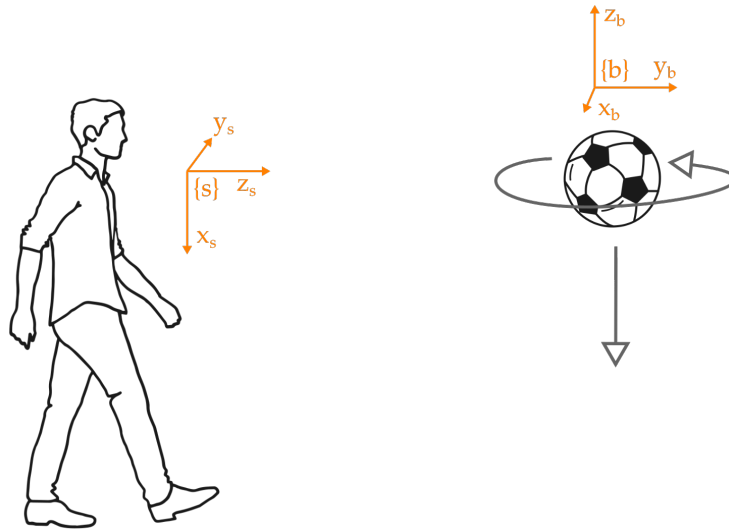
Let V be a twist. What are the dimensions of V ? What are the units of V ?

Problem 2

Write out $[V]$ for the following twist V . Is $[V]$ a transformation matrix?

$$V = \begin{bmatrix} 0 \\ 0 \\ 1 \\ -5 \\ 0 \\ 0 \end{bmatrix} \quad (1)$$

Problem 3



The ball is rotating around the z_b axis at 5 radians per second, and is falling towards the ground at 2 meters per second. If the ball is 3 meters directly in front of the human:

- What is the body twist?
- What is the spatial twist?

Problem 1

Let V be a twist. What are the dimensions of V ? What are the units of V ?

Twist V is a 6×1 vector. The top three elements capture the angular velocity — these elements have units like radians per second. The bottom three elements capture the linear velocity, and have units like meters per second.

Problem 2

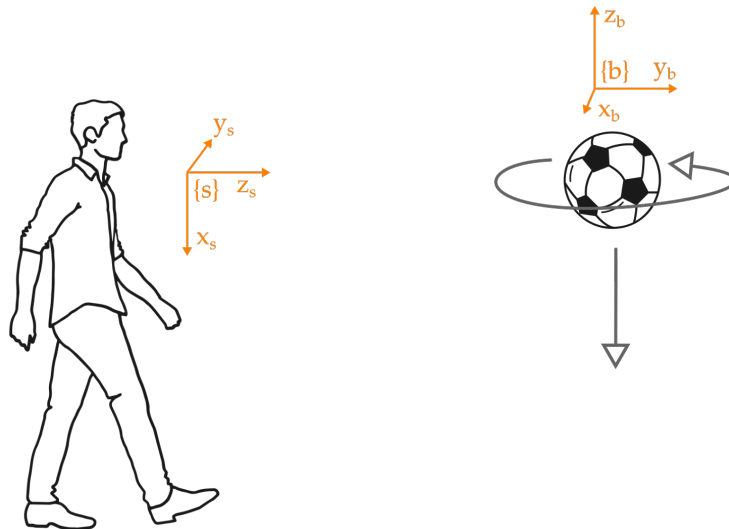
Write out $[V]$ for the following twist V . Is $[V]$ a transformation matrix?

$$V = \begin{bmatrix} 0 \\ 0 \\ 1 \\ -5 \\ 0 \\ 0 \end{bmatrix} \quad (2)$$

$$[V] = \begin{bmatrix} 0 & -1 & 0 & -5 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad (3)$$

No $[V]$ is not a transformation matrix. For a transformation matrix the bottom right element is always 1, but for $[V]$ it is always zero.

Problem 3



The ball is rotating around the z_b axis at 5 radians per second, and is falling towards the ground at 2 meters per second. If the ball is 3 meters directly in front of the human:

- What is the body twist?

From the drawing we can see that the ball is rotating around the z_b axis and is translating along the $-z_b$ axis. The body twist is:

$$V_b = \begin{bmatrix} 0 \\ 0 \\ 5 \\ 0 \\ 0 \\ -2 \end{bmatrix} \quad (4)$$

- What is the spatial twist?

From the drawing we can see that the ball is rotating around the $-x_s$ axis and is translating along the x_s axis. Here $\omega_s = [-5, 0, 0]^T$ and $\dot{p}_{sb} = [2, 0, 0]^T$. We also need to account for the linear velocity at $\{s\}$ due to the angular velocity of the ball. Here $p_{sb} = [0, 0, 3]^T$. The spatial twist is:

$$V_s = \begin{bmatrix} \omega_s \\ -\omega_s \times p + \dot{p} \end{bmatrix} = \begin{bmatrix} -5 \\ 0 \\ 0 \\ 2 \\ -15 \\ 0 \end{bmatrix} \quad (5)$$