

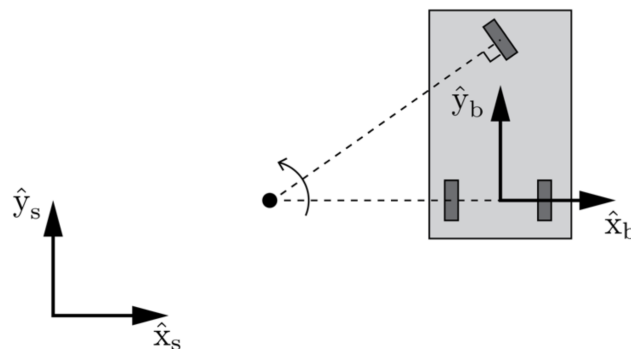
ME 449 Fall 2026

Assignment 2

Due Friday, Oct 23, 1:30 pm

For these exercises, use the MR software where helpful.

1. Exercise 3.5.
2. Exercise 3.6.
3. Exercise 3.16.
4. Draw a frame and a screw axis in that frame $S = (1, 0, 0, 0, 0, -2)$. Give an example $(q, \hat{s}, h)$ representation of S .
5. In class, we studied the case of a car driving forward with a constant turning radius (about a rotation axis a distance 2 units from the origin of the car's $\{b\}$ frame, as shown in the image below). The origin of the $\{b\}$ frame is at $(4, 1, 0)$ in $\{s\}$ coordinates.



- (a) What is T_{sb} for the car's current configuration, as shown?
- (b) What is the screw axis S_b corresponding to the car's motion, expressed in the $\{b\}$ frame?
- (c) What is the screw axis S_s corresponding to the car's motion, expressed in the $\{s\}$ frame?
- (d) Give $\exp([S_s] \pi/2) T_{sb}$. You should interpret the matrix exponential as moving the car to a new frame $\{b'\}$. Explain how the matrix exponential moves the car. Draw $\{s\}$, $\{b\}$, and $\{b'\}$ in a single figure.
- (e) Give $T_{sb} \exp([S_s] \pi/2)$. (There is no typo!) You should interpret the matrix exponential as moving the car to a new frame $\{b'\}$. Explain how the matrix exponential moves the car. Draw $\{s\}$, $\{b\}$, and $\{b'\}$ in a single figure. Also in that figure, draw the screw axis that the car followed.

- (f) Give $\exp([S_b] \pi/2) T_{sb}$. You should interpret the matrix exponential as moving the car to a new frame $\{b'\}$. Explain how the matrix exponential moves the car. Draw $\{s\}$, $\{b\}$, $\{b'\}$, and the screw axis the car followed in a single figure.
6. Let T_{cd} represent the $\{d\}$ frame relative to the $\{c\}$ frame. Consider a body with a frame $\{e\}$ attached to it. The frame $\{e\}$ is initially aligned with $\{c\}$. If the body follows a particular constant twist for 5 seconds, it ends up with its $\{e\}$ frame aligned with $\{d\}$. Where was the $\{e\}$ frame after following the first 2 seconds of that twist? Your answer should be in terms of T_{cd} .
 7. F_a is a wrench expressed in $\{a\}$. How is this same wrench expressed in $\{c\}$, the configuration of which can be represented by the exponential coordinates $S\theta$ in the frame $\{a\}$?
 8. Exercise 4.2.
 9. Exercise 4.5.
 10. Exercise 4.10. Also, give the space and body Jacobians when the robot is at its home configuration.
 11. Exercise 5.2.