# Animating a Simple 2D Kinematic Steering Model

ME695B, Advanced Vehicle Dynamics

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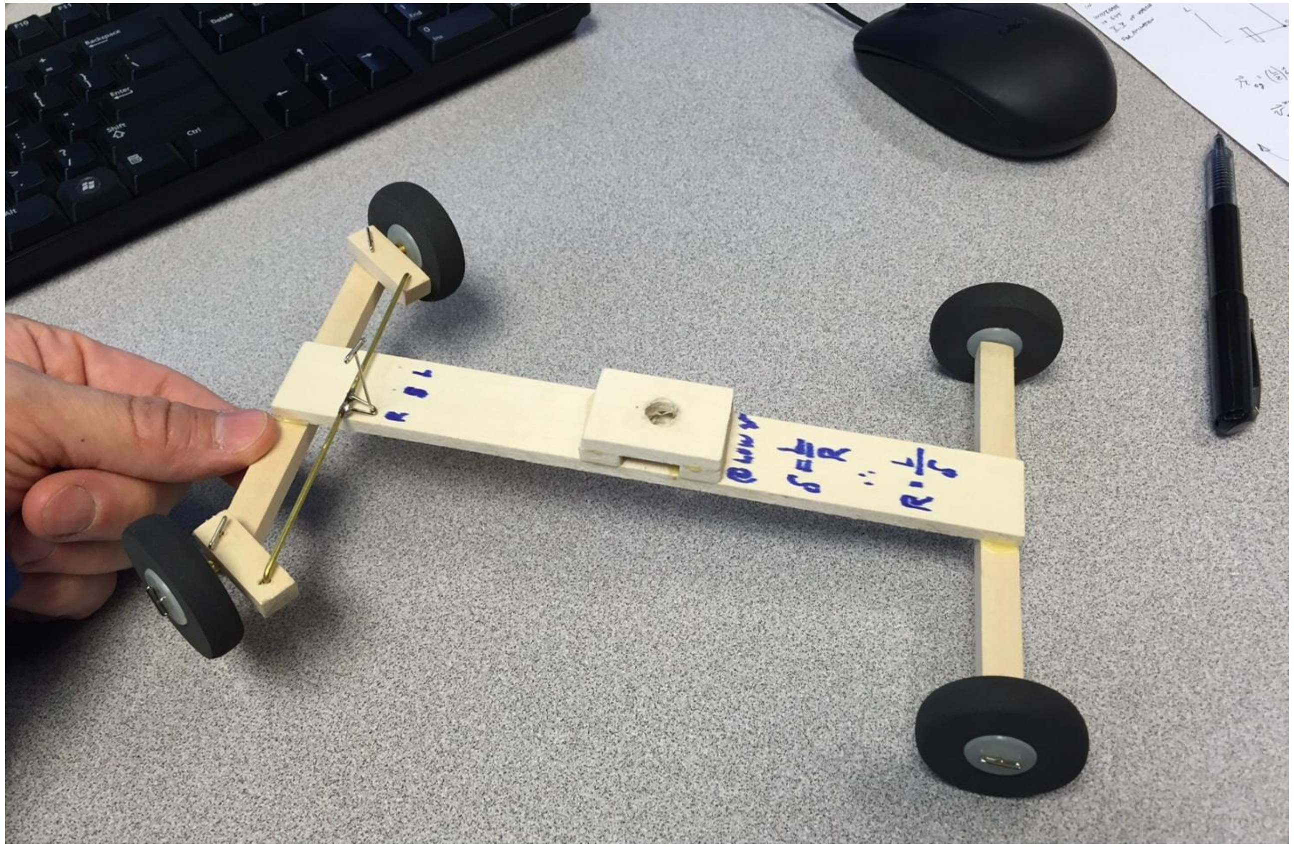
# Kinematic Steering Model – Rolling Without Slipping

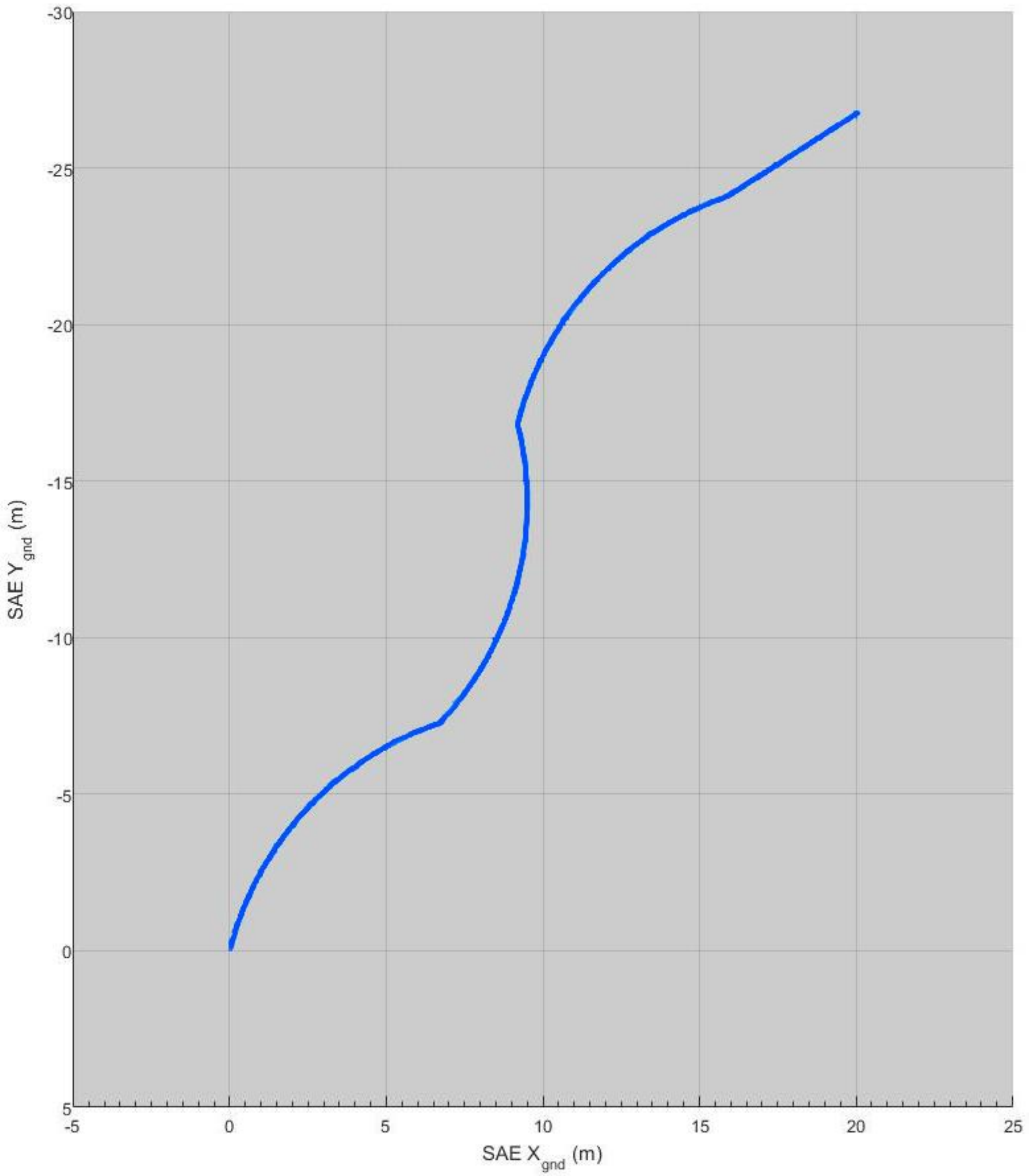
- Given this simple kinematic, low speed vehicle

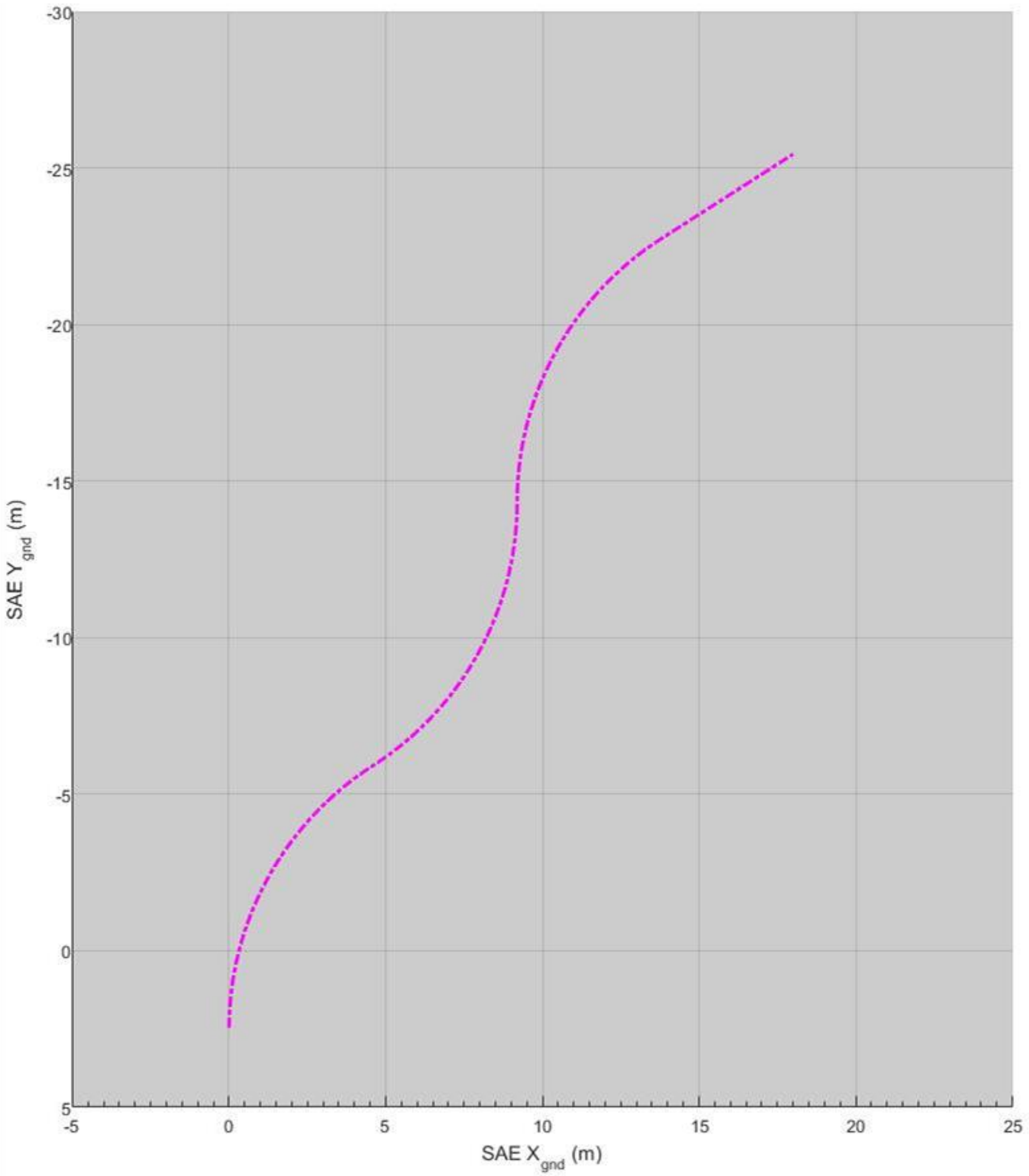
  and

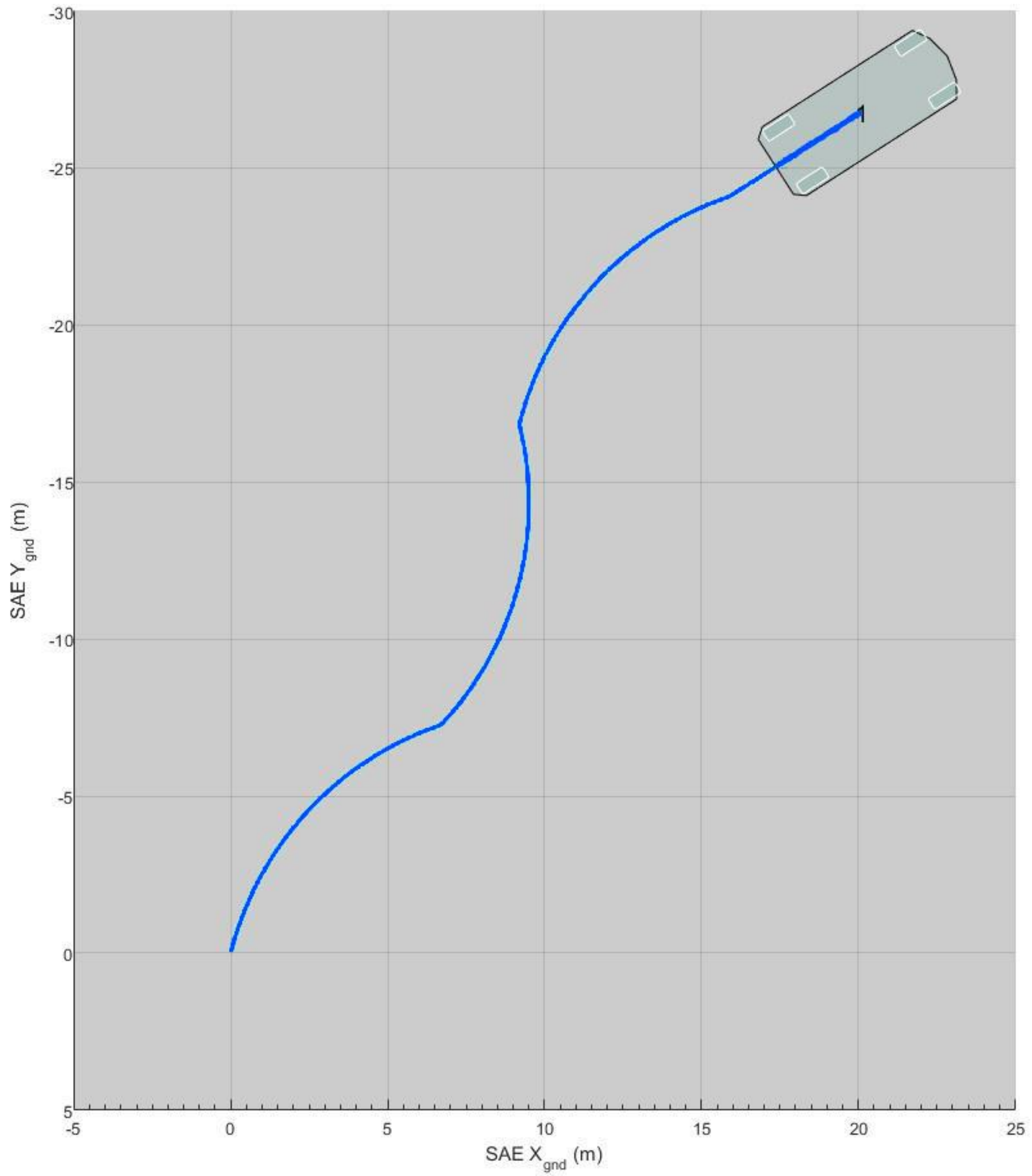
- Given a constant speed and steering input of:
  - RIGHT
  - LEFT
  - RIGHT
- Which trace do you think is correct?



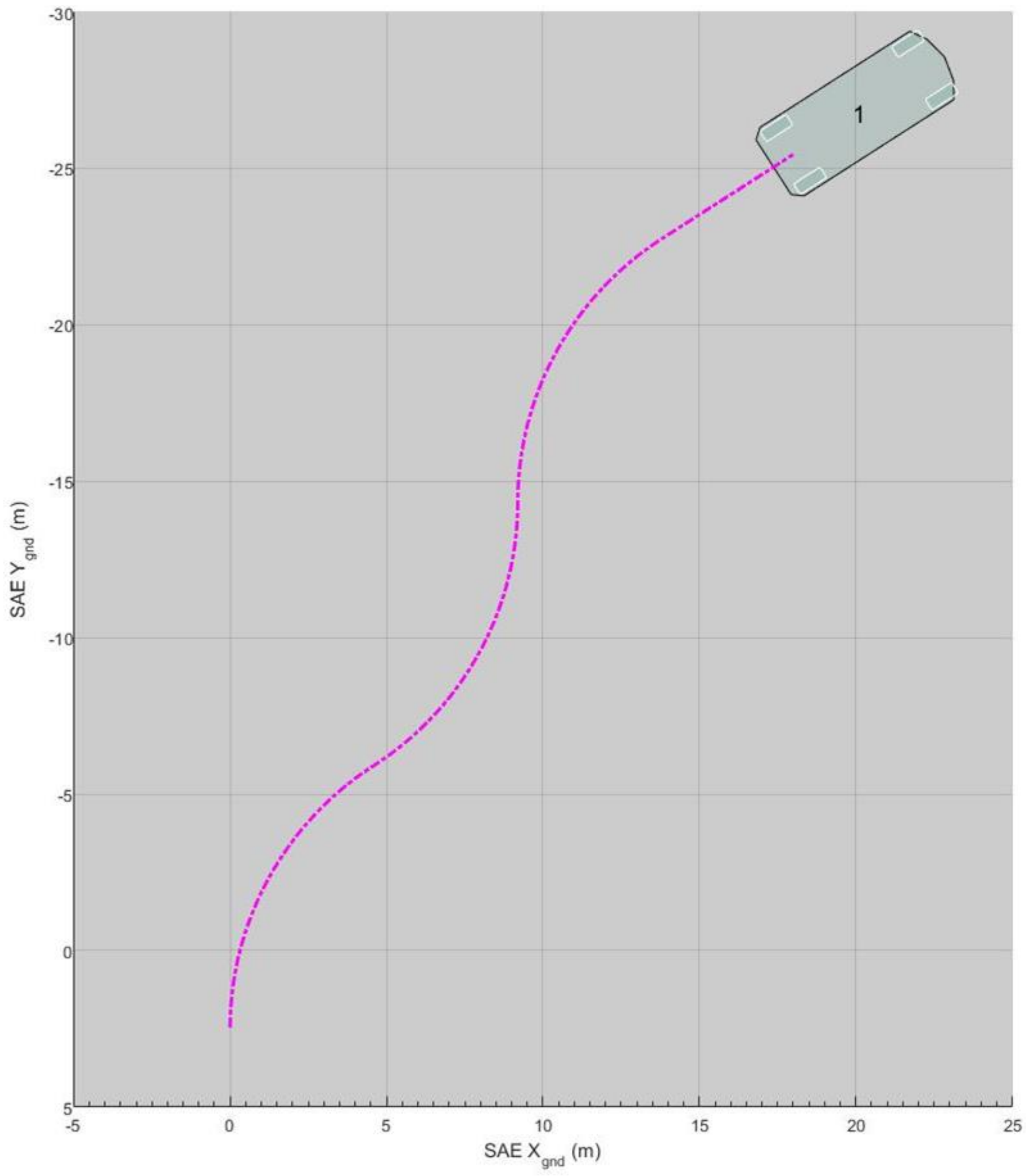
# Which trace do you think is correct, and why?





-30
-25
-20
-15
-10
-5
0
5
-5
0
5
10
15
20
25
SAE $X_{gnd}$ (m)
SAE $Y_{gnd}$ (m)


-30
-25
-20
-15
-10
-5
0
5
SAE Y$_{gnd}$ (m)
-5
0
5
10
15
20
25
SAE X$_{gnd}$ (m)
1

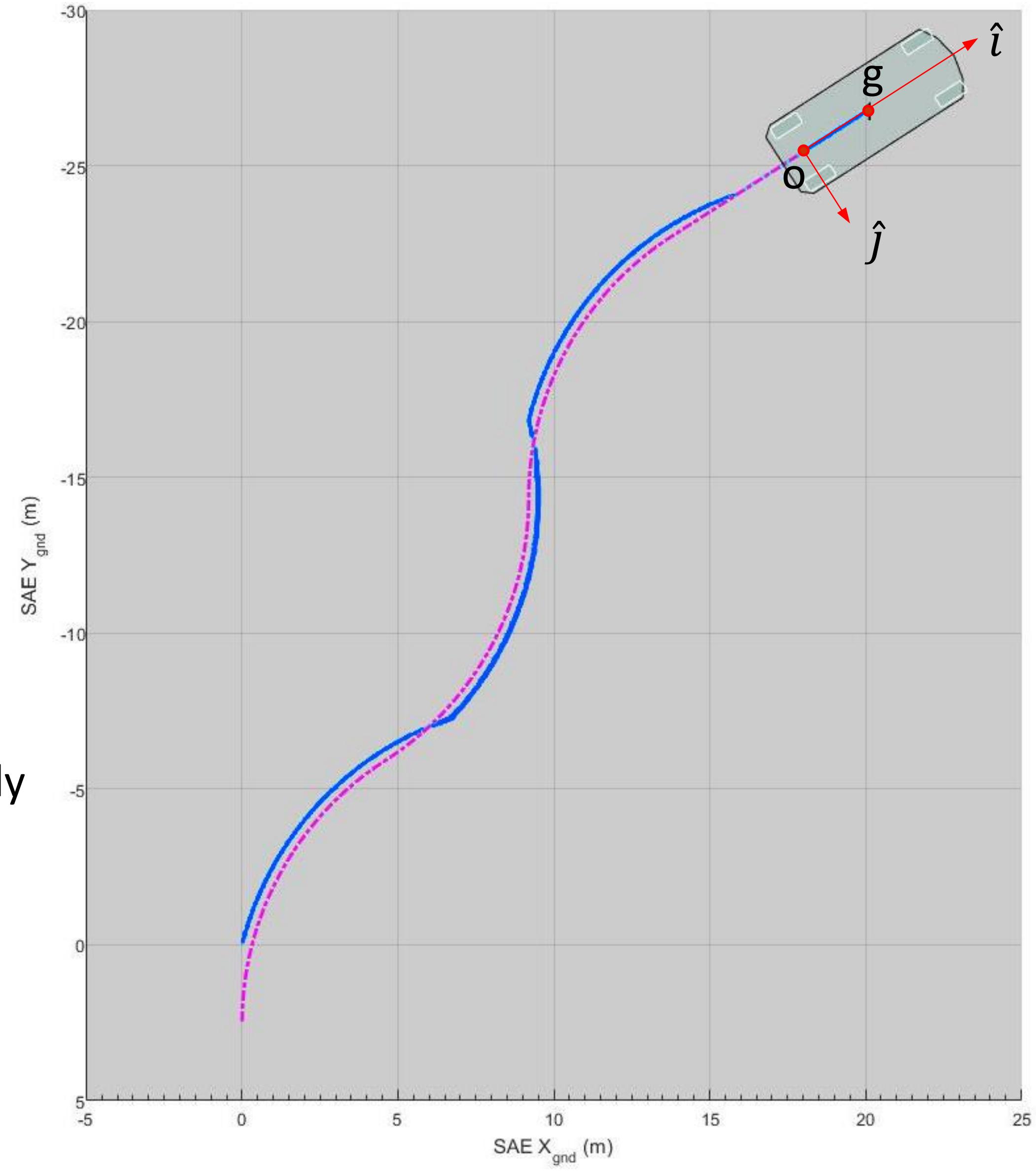
Answer:
**BOTH** traces are correct.

The trace connected by smooth, continuous segments is the position trace from the rear axle's center at point 'o':

$$v_o^{xy} = \begin{bmatrix} v_x \, \hat{\imath} \\ 0 \;\; \hat{\jmath} \end{bmatrix}$$

The trace with discontinuously connected segments is the trace from the vehicle's geometric center, 'g'.

$$v_g^{xy} = v_o^{xy} + \vec{\omega} \times \vec{r}_{og}$$




Using the coordinate transformation matrix, T, transform the velocity of point 'g' in the body-fixed xy frame to the inertial, or terrain-fixed XY frame with:

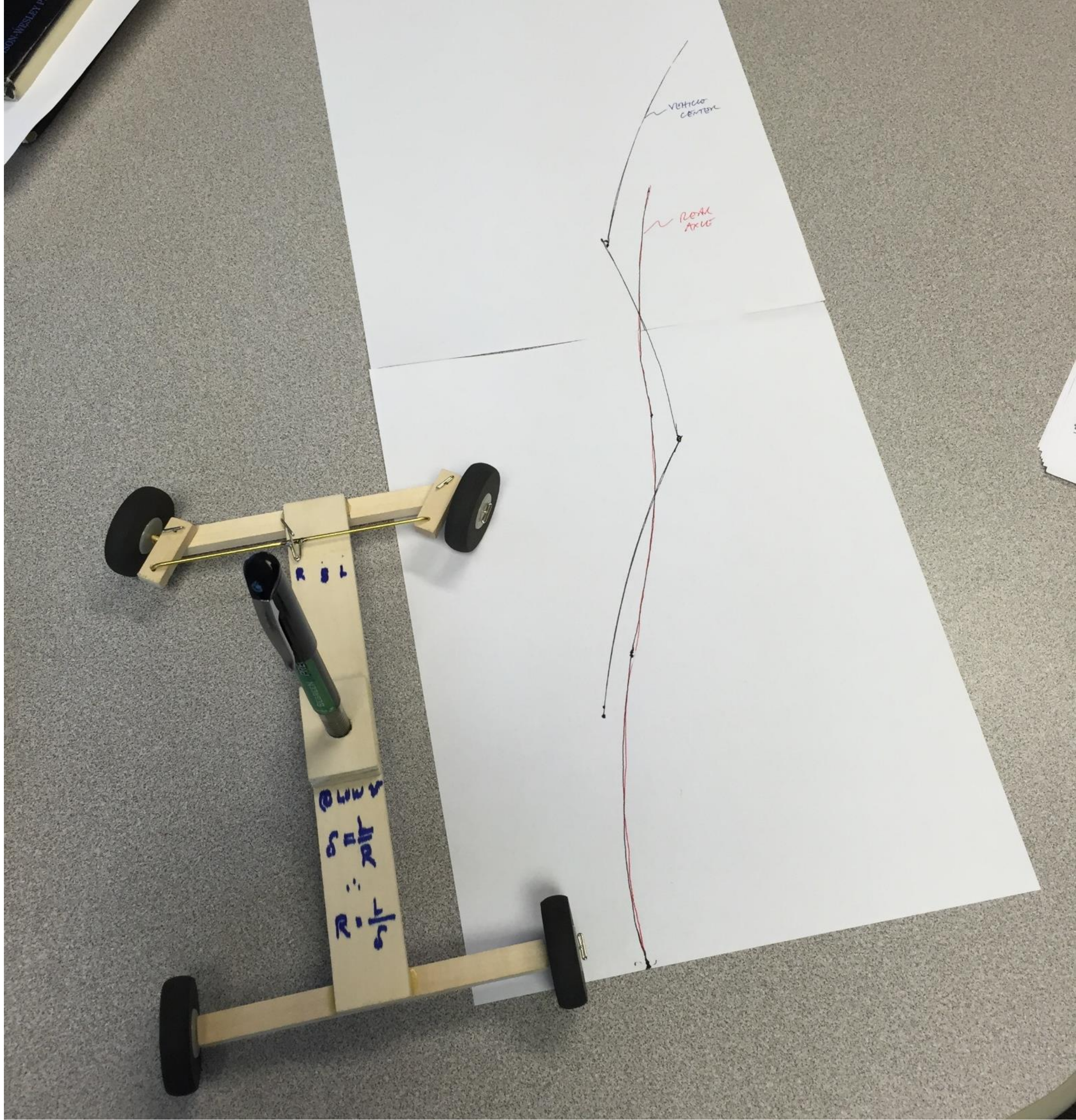
$$v_g^{XY} = \begin{bmatrix} \cos(\psi) & -\sin(\psi) \\ \sin(\psi) & \cos(\psi) \end{bmatrix} \cdot v_g^{xy}$$

Then integrate the terrain-frame velocities to achieve position in XY as a function of body-fixed steering input, delta:

$$\begin{bmatrix} X_g \\ Y_g \end{bmatrix} = \int v_g^{XY} \, dt \qquad \psi = \int \dot{\psi} \, dt$$

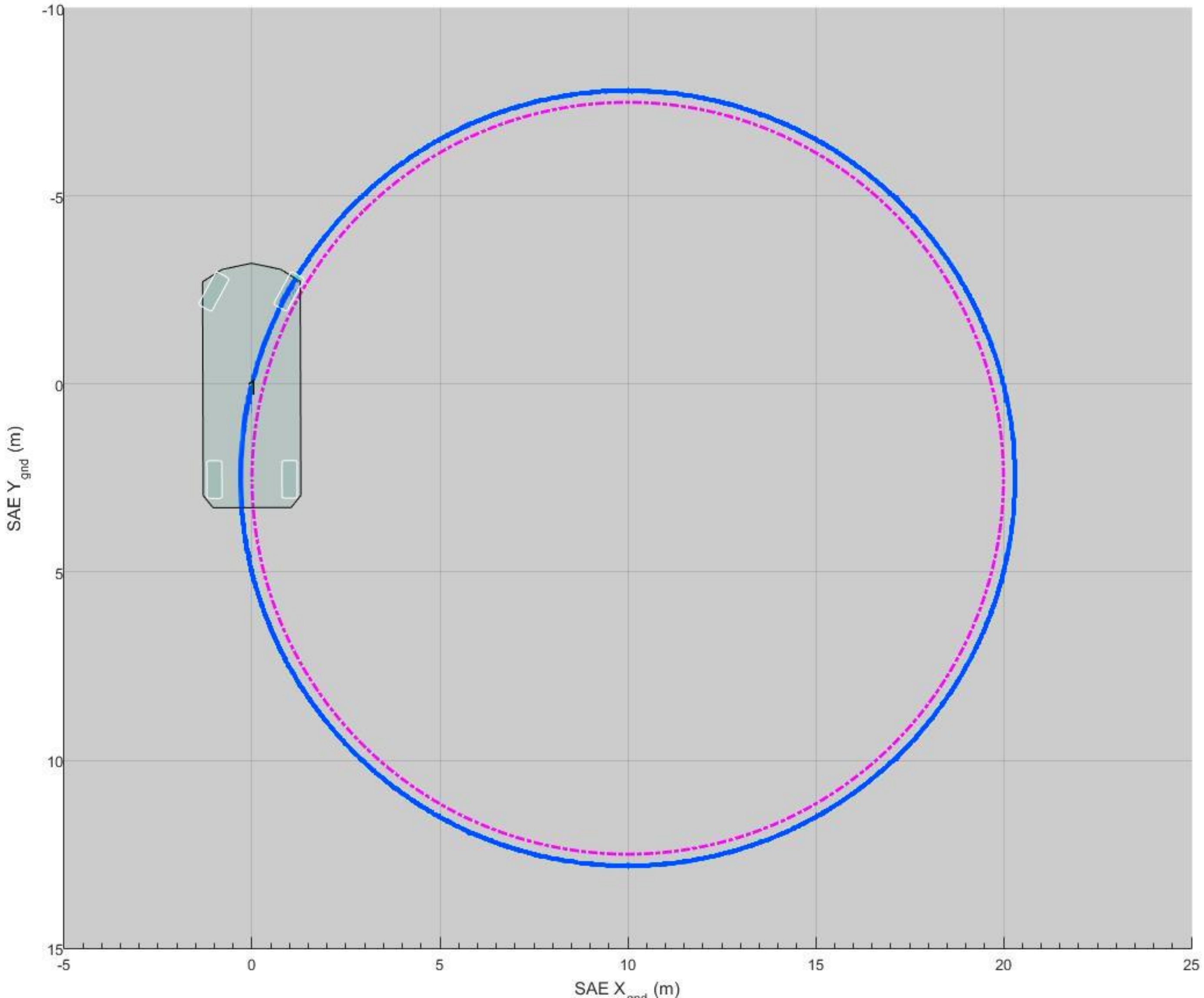
$$\dot{\psi} = \left(\frac{v_x}{L}\right) \delta_{steer}$$

- Dragging the pen while moving the car shows the smooth rear axle trace and the vehicle center trace.
- The smooth trace is from the center of the rear axle, at 'o'
- The discontinuous trace is from the pen's trace at the center of the vehicle, at 'g'



# Constant Radius Turning Scenarios

# Turning with Constant Radius. Where is the circle centered?



# Tangential Entry and Exit