

# Reference Frames Continued and Examples

AERSP 304 - Dynamics and Control of Aerospace Systems

V.T. Valente

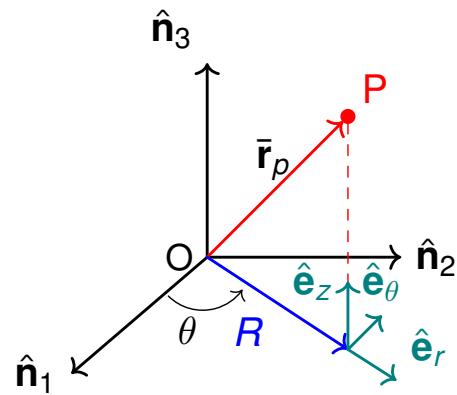
Penn State University

January 16, 2026

## Goals for Today

- ▶ Continue review of Frame of References
- ▶ Analyze velocity and acceleration in different frames
- ▶ Examples

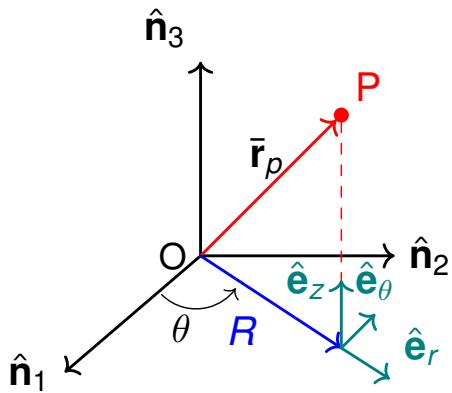
## Reference Frames and Velocity



# Writing a DCM for a Simple Rotation

Steps for a simple rotation DCM:

1. Identify the axis of rotation (here:  $\hat{\mathbf{n}}_3 \equiv \hat{\mathbf{e}}_z$ ).
2. Visualize in 2D by looking through the axis of rotation.



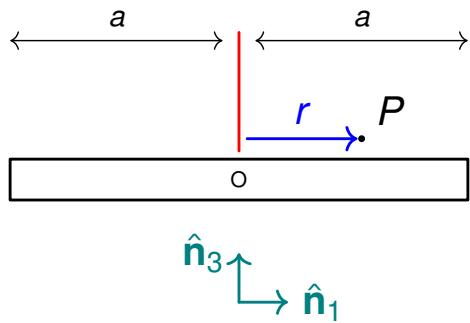
What about Acceleration?

## Example: Tug-of-War on a Rotating Platform

In a game of Tug-of-War, participants are constrained to move only along a narrow platform. Moreover, the platform is rotating at angular velocity  $\dot{\theta} \hat{\mathbf{n}}_3$ . They move back and forth so that the distance from the center of the platform a point  $P$  (point mass) is given by

$$r(t) = \frac{a}{2} (1 + \sin(\omega t))$$

Find the *inertial* acceleration of  $P$ .



### Step 1: Define Frames

## Step 2: Write the DCM

1. Identify the axis of rotation (here:  $\hat{n}_3$ ).
2. Visualize in 2D by looking through the axis of rotation.

## Step 3: Position, Velocity, and Acceleration of $P$

## Step 3: ...Continued

### Summary

- ▶ Reference frames are essential to describe motion
- ▶ Direction Cosine Matrices (DCMs) allow us to convert vectors between frames
  1. Identify the axis of rotation
  2. Visualize in 2D by looking through the axis of rotation
- ▶ Velocity and acceleration in rotating frames have additional terms