1. Mathematical Model for Differential Drive Robot

A. Assumptions:

- Robot has two wheels (differential drive).
- Operates on a 2D plane.
- No wheel slip (non-holonomic constraint).
- Pose is (x, y, θ): position and orientation.

B. Kinematic Equations

Let:

- $x(t), y(t)$: position of robot
- $\theta(t)$: heading angle
- v: linear velocity (m/s)
- ω: angular velocity (rad/s)

Differential drive model:

$$\dot{x} = v\cos(\theta)$$

$$\dot{y} = v\sin(\theta)$$

$$\dot{\theta} = \omega$$

If you control the left and right wheel velocities (v_L, v_R) and the wheel separation is L:

$$v = \frac{v_R + v_L}{2} \quad , \quad \omega = \frac{v_R - v_L}{L}$$

C. Path Following (e.g., Circular or Arbitrary)

To simulate, we can:

- Predefine a **circular path**: $(x(t), y(t)) = (R\cos(\omega t), R\sin(\omega t))$
- Simulate robot movement using control inputs toward next waypoint on path