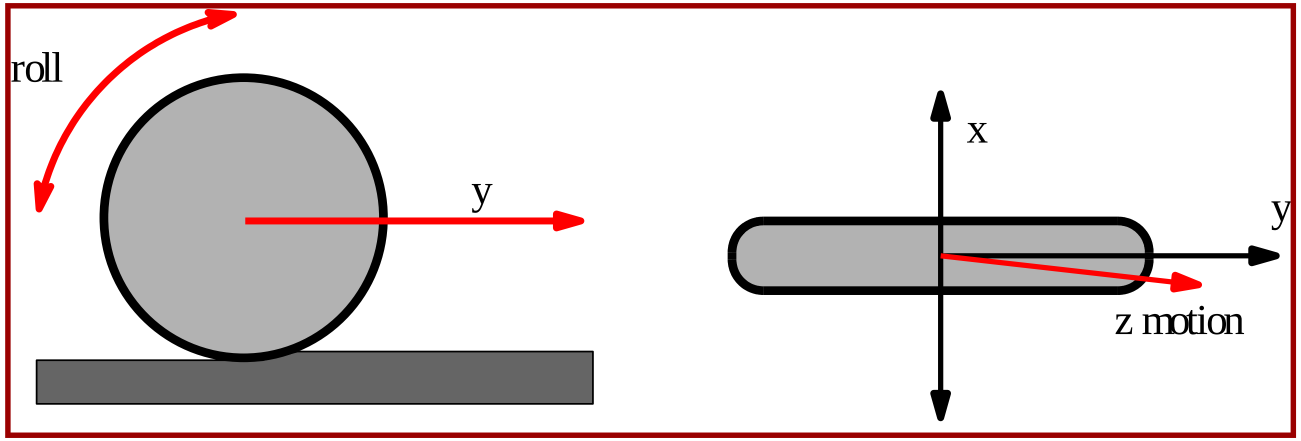
Locomotion of Wheeled Robots

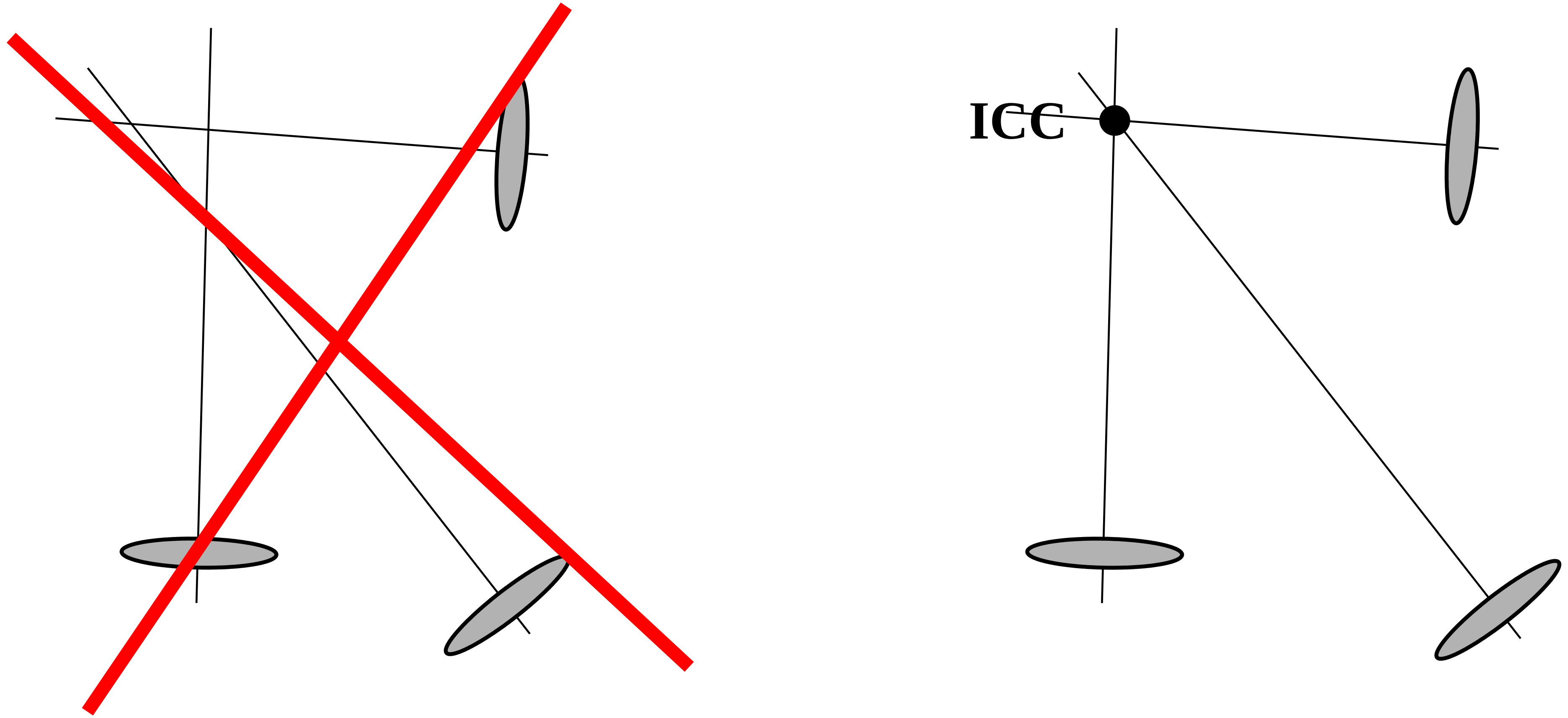
Locomotion (Oxford Dict.): Power of motion from place to place

- Differential drive (AmigoBot, Pioneer 2-DX)
- Car drive (Ackerman steering)
- Synchronous drive (B21)
- XR4000
- Mecanum wheels



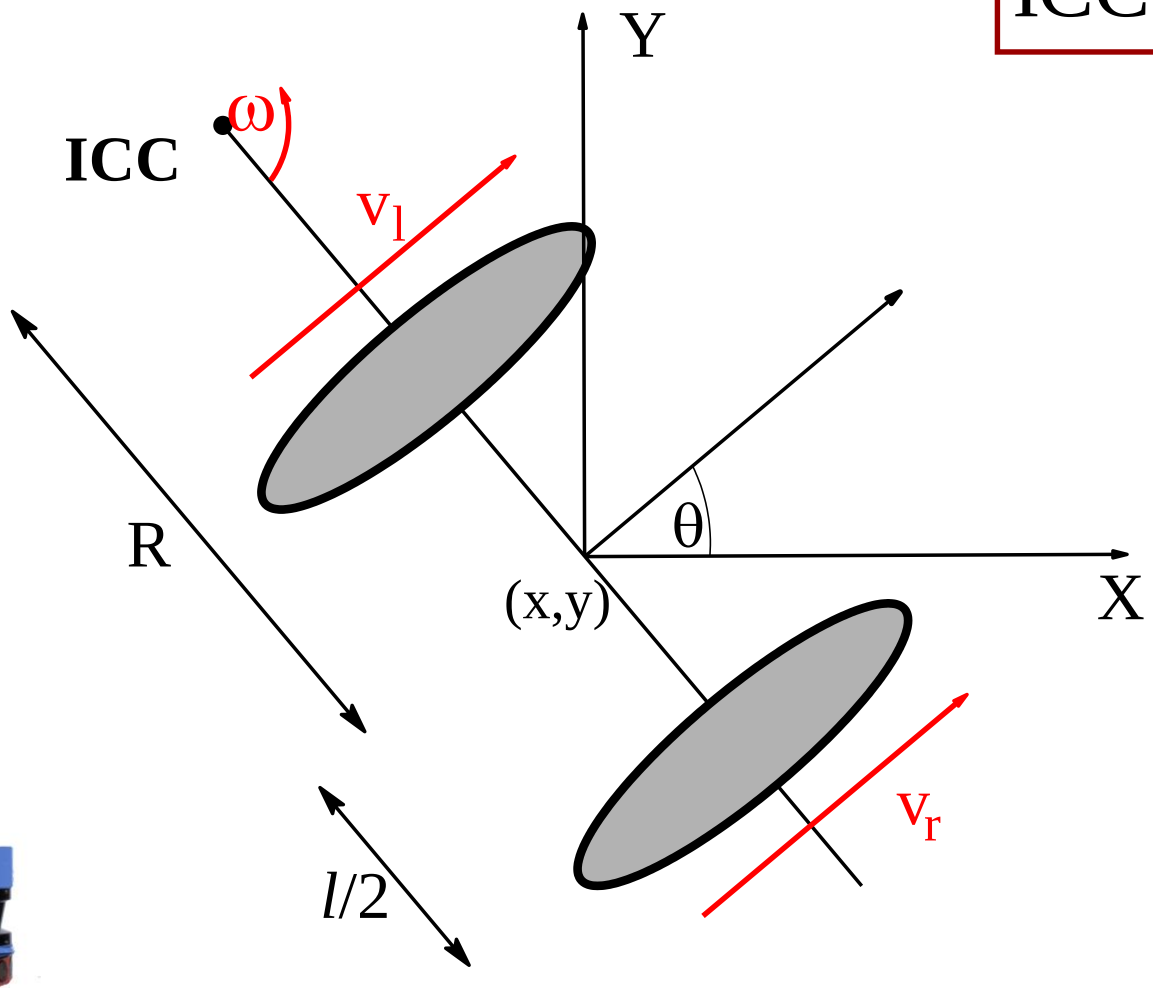
we also allow wheels to rotate around the z axis

Instantaneous Center of Curvature



- For rolling motion to occur, each wheel has to move along its y-axis

Differential Drive



$$ICC = [x - R\sin\theta, y + R\cos\theta]$$

$$w(R + l/2) = v_r$$

$$w(R - l/2) = v_l$$

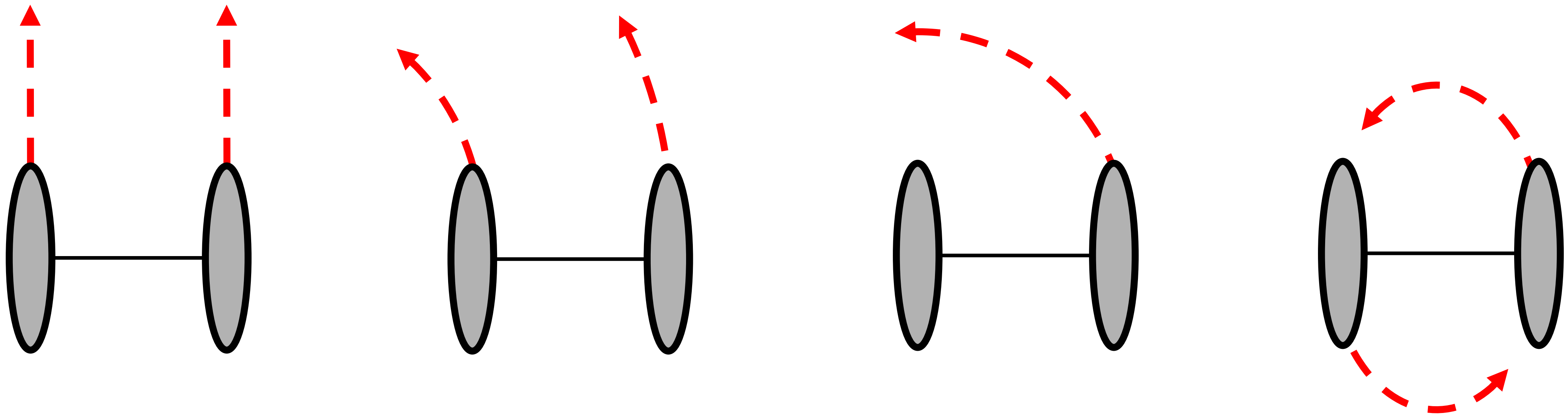
$$R = \frac{l}{2}\frac{(v_l + v_r)}{(v_r - v_l)}$$

$$w = \frac{v_r - v_l}{l}$$

$$v = \frac{v_r + v_l}{2}$$

Differential Drive Motion Patterns

$$R = \frac{l}{2}\frac{(v_l + v_r)}{(v_r - v_l)}, \qquad \omega = \frac{v_r - v_l}{l}$$



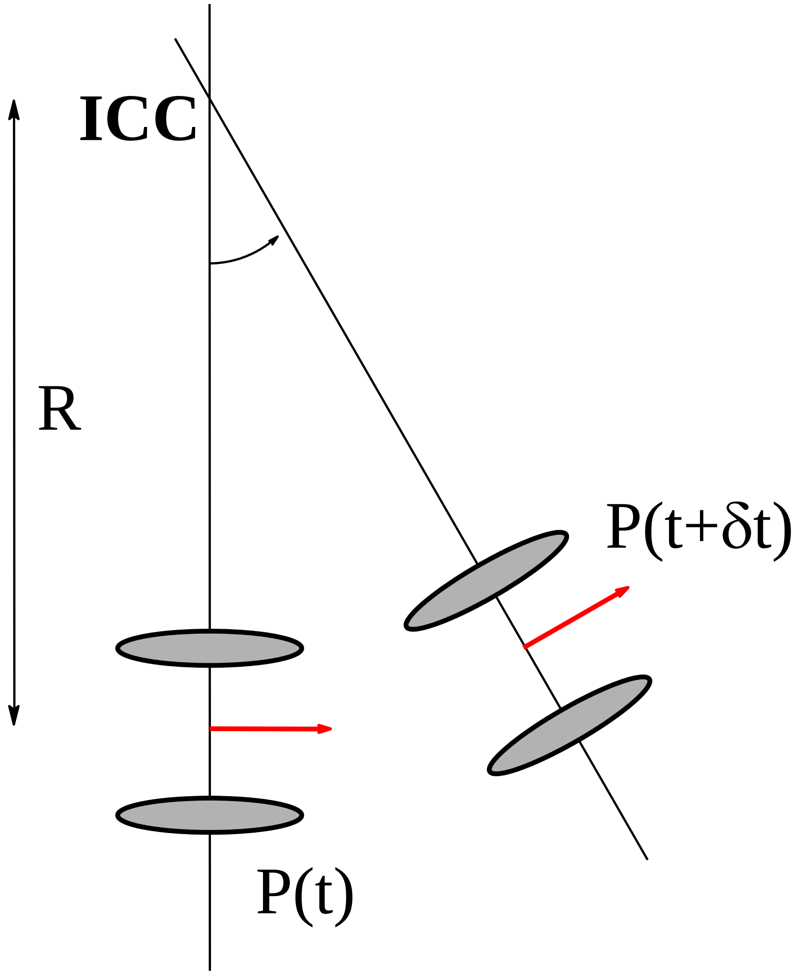
$v_l = v_r$

$v_l < v_r$
$v_l > 0$

$v_l = 0$
$v_r > 0$

$v_l = -v_r$

Differential Drive: Forward Kinematics



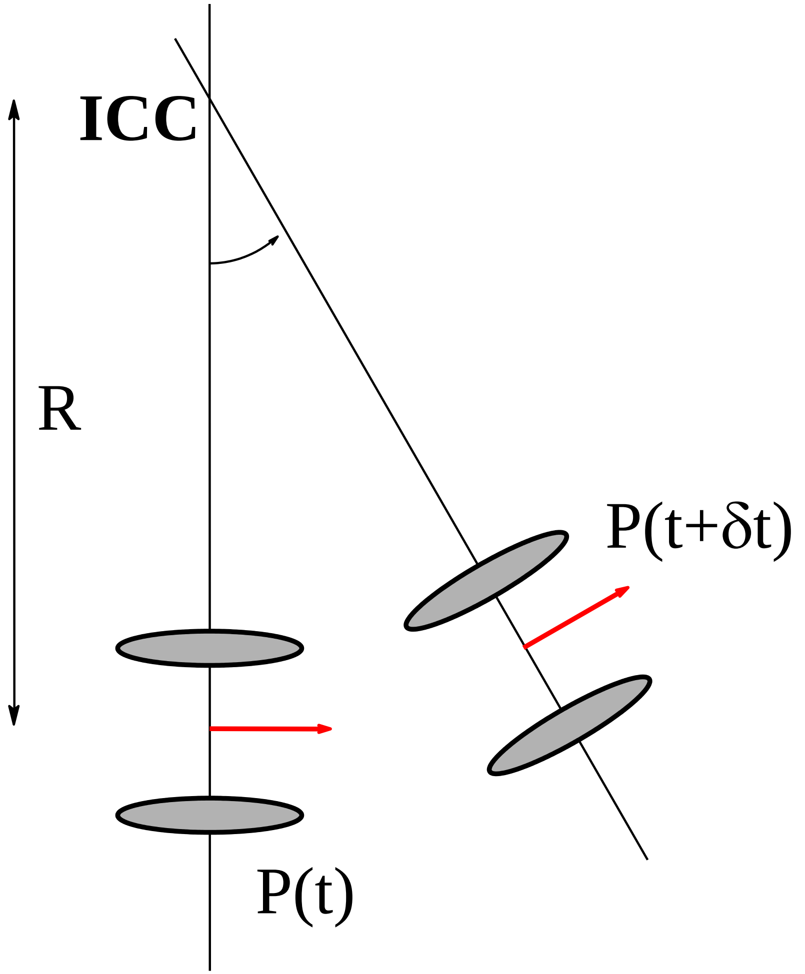
$$\begin{bmatrix} x' \\ y' \\ \theta' \end{bmatrix} = \begin{bmatrix} \cos(\omega\delta t) & -\sin(\omega\delta t) & 0 \\ \sin(\omega\delta t) & \cos(\omega\delta t) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x - ICC_x \\ y - ICC_y \\ \theta \end{bmatrix} + \begin{bmatrix} ICC_x \\ ICC_y \\ \omega\delta t \end{bmatrix}$$

$$x(t) = \int_0^t v(t') \cos[\theta(t')]dt'$$

$$y(t) = \int_0^t v(t') \sin[\theta(t')]dt'$$

$$\theta(t) = \int_0^t \omega(t')\, dt'$$

Differential Drive: Forward Kinematics



$$\begin{bmatrix} x' \\ y' \\ \theta' \end{bmatrix} = \begin{bmatrix} \cos(\omega\delta t) & -\sin(\omega\delta t) & 0 \\ \sin(\omega\delta t) & \cos(\omega\delta t) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x - \mathrm{ICC}_x \\ y - \mathrm{ICC}_y \\ \theta \end{bmatrix} + \begin{bmatrix} \mathrm{ICC}_x \\ \mathrm{ICC}_y \\ \omega\delta t \end{bmatrix}$$

$$x(t) = \frac{1}{2}\int_0^t [v_r(t') + v_l(t')] \cos[\theta(t')]dt'$$

$$y(t) = \frac{1}{2}\int_0^t [v_r(t') + v_l(t')] \sin[\theta(t')]dt'$$

$$\theta(t) = \frac{1}{l}\int_0^t [v_r(t') - v_l(t')]\, dt'$$