



## Kinematics

1. Give the formula of the rotation matrix for yaw, i.e. rotation around the  $Z$ -axis, as a function of  $\theta$ , the angle by which we rotate. Show the derivation graphically.

2. Derive the sliding constraint for a wheel at the origin of the robot frame, **aligned with the Y-axis** of the robot.

(a) first, on the instantaneous velocity  $\dot{\xi}_R$  in the robot frame  $R$ :

(b) second, on the instantaneous velocity  $\dot{\xi}_I$  in the inertial (global/reference) frame  $I$ :