Mobile Robotics Exam # 1

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1.

	SW1	SW2	Castor
α	30	150	270
β	0	0	0
γ	0	0	N/A
d	N/A	N/A	1.5
l	3.464	3.464	2
r	2	2	1

$$\begin{bmatrix} J_1(\beta_s) \\ C_1(\beta_s) \end{bmatrix} R(\theta)\dot{\varepsilon}_I = \begin{bmatrix} J_2\dot{\phi} \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} \begin{bmatrix} \sin(\alpha+\beta_c(t)) & -\cos(\alpha+\beta_c(t)) & -l_c\cos(\alpha+\beta_c(t)) \\ \sin(30) & -\cos(30) & -l_{S1}\cos(30) \\ \sin(150) & -\cos(150) & -l_{S2}\cos(150) \end{bmatrix} \\ \begin{bmatrix} \cos(\alpha+\beta_c(t)) & \sin(\alpha+\beta_c(t)) & l_c\sin(\alpha+\beta_c(t)) \\ \cos(30) & \sin(30) & l_{S1}\sin(0) \\ \cos(150) & \sin(150) & l_{S2}\sin(0) \end{bmatrix} \end{bmatrix} R(\theta)\dot{\varepsilon}_I = \begin{bmatrix} \begin{bmatrix} r_c\dot{\phi}_c \\ r_{S1}\dot{\phi}_{S1} \\ r_{S2}\dot{\phi}_{S2} \end{bmatrix} \\ \begin{bmatrix} d\dot{\beta}_c \\ r_{sw}\dot{\phi}_{sw1} \\ r_{sw}\dot{\phi}_{sw2} \end{bmatrix} \end{bmatrix}$$

We can remove rows 1, 5, & 6 as they do not imply any constraints on this system.

$$\begin{bmatrix} \sin(30) & -\cos(30) & -l_{S1}\cos(30) \\ \sin(150) & -\cos(150) & -l_{S2}\cos(150) \\ \cos(\alpha+\beta_c(t)) & \sin(\alpha+\beta_c(t)) & l_c\sin(\alpha+\beta_c(t)) \end{bmatrix} R(\theta)\dot{\varepsilon}_I = \begin{bmatrix} r_{S1}\dot{\phi}_{S1} \\ r_{S2}\dot{\phi}_{S2} \\ d\dot{\beta}_c \end{bmatrix}$$

$$\begin{bmatrix} 0.5 & -0.866 & -3.464 \\ 0.5 & 0.866 & -3.464 \\ \cos(\alpha+\beta_c(t)) & \sin(\alpha+\beta_c(t)) & 2\sin(\alpha+\beta_c(t)) \end{bmatrix} R(\theta)\dot{\varepsilon}_I = \begin{bmatrix} 2\dot{\phi}_{S1} \\ 2\dot{\phi}_{S2} \\ 1.5\dot{\beta}_c \end{bmatrix}$$

2. $\dot{\varepsilon}_I = R(\theta)^{-1} \begin{bmatrix} 0.5 & -0.866 & -3 \\ 0.5 & 0.866 & 3 \\ \cos(270) & \sin(270) & 2\sin(270) \end{bmatrix}^{-1} \begin{bmatrix} 2*1.25 \\ 2*1.2 \\ 0 \end{bmatrix} = \begin{bmatrix} 4.9 \text{ m/s} \\ -0.0789 \text{ m/s} \\ 0.0394 \text{ rad/s} \end{bmatrix}$

3. $\delta_m = 3 - \text{rank}[C_1(\beta_s(t))] = 2$

4. $\delta_s = \text{rank}[C_{1s}(\beta_s(t))] = 0$

5. $\delta_M = \delta_m + \delta_s = 2$

6. DDOF is 2, the robot can move forwards/backwards, left/right. DOF is 3, the robot can move in the x, y, and yaw directions.

7.