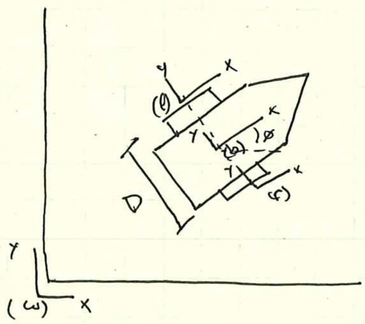

$$T_{wb} = \begin{bmatrix} \cos\phi & -\sin\phi & x \\ \sin\phi & \cos\phi & y \\ 0 & 0 & 1 \end{bmatrix}$$

$$T_{br} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & \frac{D}{2} \\ 0 & 0 & 1 \end{bmatrix} \qquad T_{bl} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -\frac{D}{2} \\ 0 & 0 & 1 \end{bmatrix}$$

(1) GET THE BODY TWIST ~~IN~~ INTO EACH WHEEL FRAME:

$$\mathcal{V}_r = Ad_{T_{br}} \mathcal{V}_b \qquad \mathcal{V}_l = Ad_{T_{bl}} \mathcal{V}_b$$

$$\mathcal{V}_r = \begin{bmatrix} 1 & 0 & 0 \\ \frac{D}{2} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \dot\phi_b \\ \dot x_b \\ \dot y_b \end{bmatrix} \qquad \mathcal{V}_l = \begin{bmatrix} 1 & 0 & 0 \\ -\frac{D}{2} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \dot\phi_b \\ \dot x_b \\ \dot y_b \end{bmatrix}$$

$$\mathcal{V}_r = \begin{bmatrix} \dot\phi_b \\ \frac{D}{2}\dot\phi_b + \dot x_b \\ \dot y_b \end{bmatrix} \quad (Eq.\ 1) \qquad \mathcal{V}_l = \begin{bmatrix} \dot\phi_b \\ -\frac{D}{2}\dot\phi_b + \dot x_b \\ \dot y_b \end{bmatrix} \quad (Eq.\ 2)$$

(2) PROPERTIES OF CONVENTIONAL WHEELS:

$$\begin{aligned} V_x &= (u) r \\ V_y &= 0 \end{aligned} \quad (Eq.\ 3)$$

(3) SOLVE FOR u FOR EACH WHEEL:

$$\mathcal{V}_r = \begin{bmatrix} \dot\phi_r \\ u_r r \\ 0 \end{bmatrix} = \begin{bmatrix} \dot\phi_b \\ \frac{D}{2}\dot\phi_b + \dot x_b \\ \dot y_b \end{bmatrix} \qquad \mathcal{V}_l = \begin{bmatrix} \dot\phi_l \\ u_l r \\ 0 \end{bmatrix} \begin{bmatrix} \dot\phi_b \\ -\frac{D}{2}\dot\phi_b + \dot x_b \\ \dot y_b \end{bmatrix}$$

$$u_r = \frac{1}{r}\left(\frac{D}{2}\dot\phi_b + \dot x_b\right) \qquad u_l = \frac{1}{r}\left(-\frac{D}{2}\dot\phi_b + \dot x_b\right)$$

$$\begin{bmatrix} u_r \\ u_l \end{bmatrix} = \frac{1}{r}\begin{bmatrix} \frac{D}{2} & 1 & 0 \\ -\frac{D}{2} & 1 & 0 \end{bmatrix} \begin{bmatrix} \dot\phi_b \\ \dot x_b \\ \dot y_b \end{bmatrix} \quad (Eq.\ 4)$$

$$u = H \nu_b \rightarrow \nu_b = H^{+} u$$

IN ORDER TO FIND THE PSEUDOINVERSE OF H, USE THE FOLLOWING:

$$H^{+} = H^{T}\left(H H^{T}\right)^{-1}$$

BECAUSE THE MATRIX IS FULL RANK W.R.T. THE ROWS.

$$H^{+} = r\begin{bmatrix} \frac{D}{2} & -\frac{D}{2} \\ 1 & 1 \\ 0 & 0 \end{bmatrix}\left(\begin{bmatrix} \frac{D}{2} & 1 & 0 \\ -\frac{D}{2} & 1 & 0 \end{bmatrix}\begin{bmatrix} \frac{D}{2} & -\frac{D}{2} \\ 1 & 1 \\ 0 & 0 \end{bmatrix}\right)^{-1}$$

$$= \text{''} \qquad \text{''} \left(\begin{bmatrix} \frac{D^2}{4}+1 & -\frac{D^2}{4}+1 \\ -\frac{D^2}{4}+1 & \frac{D^2}{4}+1 \end{bmatrix}\right)^{-1}$$

$$= \text{''} \qquad \text{''} \begin{bmatrix} \frac{1}{4}+\frac{1}{2D^2} & \frac{1}{4}-\frac{1}{2D^2} \\ \frac{1}{4}-\frac{1}{2D^2} & \frac{1}{4}+\frac{1}{2D^2} \end{bmatrix}$$

$$= r\begin{bmatrix} \frac{D}{2}\left(\frac{1}{4}+\frac{1}{D^2}\right) - \frac{D}{2}\left(\frac{1}{4}-\frac{1}{D^2}\right) & \frac{D}{2}\left(\frac{1}{4}-\frac{1}{D^2}\right) - \frac{D}{2}\left(\frac{1}{4}+\frac{1}{D^2}\right) \\ \left(\frac{1}{4}+\frac{1}{D^2}\right)+\left(\frac{1}{4}-\frac{1}{D^2}\right) & \left(\frac{1}{4}-\frac{1}{D^2}\right)+\left(\frac{1}{4}+\frac{1}{D^2}\right) \\ 0 & 0 \end{bmatrix}$$

$$= r\begin{bmatrix} \frac{1}{D} & -\frac{1}{D} \\ \frac{1}{2} & \frac{1}{2} \\ 0 & 0 \end{bmatrix} \qquad \text{(Eq. 5)}$$