QUIZ 1 ADV ROBOTICS Feb 2003

1. $${}^A x_B = \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix} \quad \text{(along } -z \text{ axis of } A\text{)}$$

$${}^A y_B = \begin{pmatrix} 2-3 \\ 5-0 \\ 0-0 \end{pmatrix} = \begin{pmatrix} -1 \\ 5 \\ 0 \end{pmatrix}, \text{ normalizing} = \begin{pmatrix} -1 \\ 5 \\ 0 \end{pmatrix} \cdot \frac{1}{\sqrt{1+25}}$$

$$= \begin{pmatrix} -0.196 \\ 0.981 \\ 0 \end{pmatrix}$$

$${}^A z_B = {}^A x_B \times {}^A y_B = \begin{pmatrix} 0.981 \\ 0.196 \\ 0 \end{pmatrix}, \quad {}^A p_B = \begin{pmatrix} 3 \\ 0 \\ 0 \end{pmatrix}$$

$${}^A T_B = \begin{pmatrix} 0 & -0.196 & 0.981 & 3 \\ 0 & 0.981 & 0.196 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

2. Let ${}^A T_{C_0} = {}^A T_C$ (given = initial pos + orient of C in A)

$${}^B T_{C_0} = {}^B T_A \, {}^A T_{C_0} \quad \text{where } {}^B T_A = {}^A T_B^{-1}$$

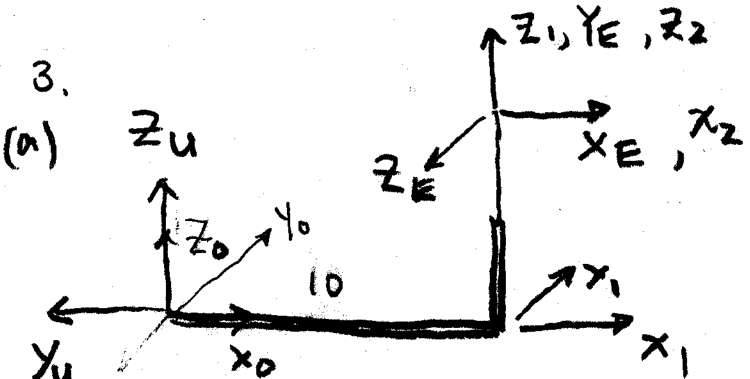
$${}^B T_{C_1} = Rot(x, 30^\circ) \, {}^B T_{C_0} = Rot(x, 30^\circ) \, {}^A T_B^{-1} \, {}^A T_{C_0}$$

$${}^B T_{C_2} = {}^B T_{C_1} \, {}^{C_1} T_{C_2} = {}^B T_{C_1} \, Trans(1,2,3)$$

$${}^A T_{C_2} = {}^A T_B \, {}^B T_{C_2} = {}^A T_B \underbrace{Rot(x, 30^\circ) \, {}^A T_B^{-1} \, {}^A T_{C_0}}_{{}^B T_{C_1}} Trans(1,2,3)$$

3.

(a)



DH Frames: 0, 1, 2 : Note: DH Frames diff from U + E

(b)

	θ	r	d	α
1	$q_1 = 0$	0	10	-90°
2	0	q_2 (0 to 10)	0	0

q_i = variables or joint coords.

$$
{}^{u}T_{0} = \begin{pmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, \quad {}^{2}T_{E} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}
$$

const. const.

c) as robot moves, ${}^{u}y_{E}$ = constant (always pointing up)

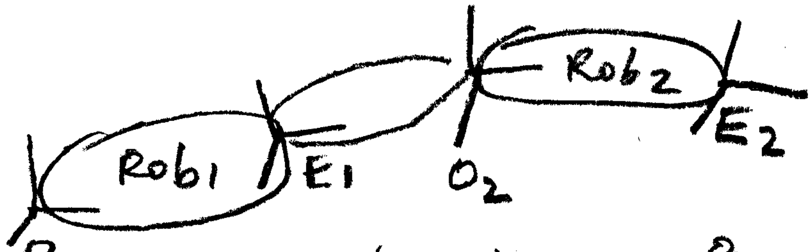
$$= \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

$\therefore$ $n_z = 0$, $a_z = 0$ always

Elements which are not constants:

$n_x, n_y, a_x, a_y, p_x, p_y, p_z$

4.



$$
{}^{o_1}V_{E_1} = \begin{pmatrix} J_{v_1} \\ J_{w_1} \end{pmatrix} \dot{q}_1, \quad {}^{o_2}V_{E_2} = \begin{pmatrix} J_{v_2} \\ J_{w_2} \end{pmatrix} \dot{q}_2
$$

$$
{}^{o_1}v_{E_2} = \underbrace{{}^{o_1}v_{E_1}}_{J_{v_1}\dot{q}_1} + {}^{o_1}R_{o_2}\underbrace{{}^{o_2}v_{E_2}}_{J_{v_2}\dot{q}_2} + \underbrace{{}^{o_1}\omega_{E_1}}_{J_{w_1}\dot{q}_1} \times \big(\underbrace{{}^{o_1}R_{E_1}\,{}^{E_1}p_{E_2}}_{{}^{o_1}p_{E_2} - {}^{o_1}p_{E_1}}\big)
$$

$$
{}^{o_1}\omega_{E_2} = \underbrace{{}^{o_1}w_{E_1}}_{J_{w_1}\dot{q}_1} + {}^{o_1}R_{o_2}\underbrace{{}^{o_2}w_2}_{J_{w_2}\dot{q}_2}
$$

, these 2 Eqns can also be obtained by differentiating ${}^{o_1}T_{E_2} = {}^{o_1}T_{E_1}\,{}^{E_1}T_{o_2}\,{}^{o_2}T_{E_2}$

combining

$$
\begin{pmatrix} {}^{o_1}v_{E_2} \\ {}^{o_1}\omega_{E_2} \end{pmatrix} = \underbrace{\begin{pmatrix} J_{v_1} + J_{w_1} \times ({}^{o_1}p_{E_2} - {}^{o_1}p_{E_1}) & {}^{o_1}R_{o_2} J_{v_2} \\ J_{w_1} & {}^{o_1}R_{o_2} J_{w_2} \end{pmatrix}}_{{}^{o_1}J_{E_2}} \begin{pmatrix} \dot{q}_1 \\ \dot{q}_2 \end{pmatrix}
$$