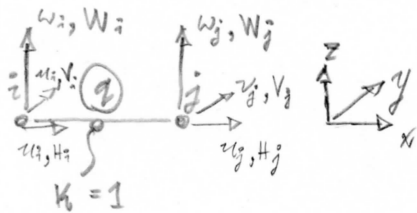## Q3)

$u_i = 1$:

$H_i = -H_j = 1(k)$

$V_i = V_j = W_i = W_j = 0$

$V_i = 1$:

$H_i = H_j = V_i = V_j = W_i = W_j = 0$

$W_i = 1$:

$H_i = H_j = V_i = V_j = W_i = W_j = 0$

$$\Rightarrow \quad \underset{\sim}{K}^{el} \begin{bmatrix} 1 & 2 & 3 & & & \\ 1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \cdot \frac{1}{k} \Rightarrow \boxed{K^{el}_{33} = 0}$$

Q4) From above,

$$\underset{\sim}{K}^{el'} = \begin{bmatrix} 1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\underset{\sim}{R}_{\theta_z} = \begin{bmatrix} C & S & 0 \\ -S & C & 0 \\ 0 & 0 & 1 \end{bmatrix} \Rightarrow \underset{\sim}{R} = \begin{bmatrix} C & S & 0 & 0 & 0 & 0 \\ -S & C & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & C & S & 0 \\ 0 & 0 & 0 & -S & C & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

let $\theta = 90 \rightsquigarrow C = \cos(90) = 0$ & $S = \sin(90) = 1$

$$\Rightarrow \underset{\sim}{R} = \begin{bmatrix} 1 & 2 & 3 & 4 & & \\ 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ \end{matrix} \Rightarrow \boxed{\left. \underset{\sim}{R}_{\theta_z = 90} \right|_{5,4} = -1}$$

Q5)

$\rightarrow A = 100 \text{ cm}^2 = 0.01 \text{ m}^2$

$L = 1 \text{ m}$

$E = 200 \text{ GPa} = 200E9 \text{ Pa}$

$v = 0.3$

$\alpha = 10^{-5} \text{ K}^{-1}$

$\Delta T = 20c = 20 \text{ K}$

$k_i = \dfrac{EA}{L} = \dfrac{200E9(0.01)}{1} = 2E9 \dfrac{\frac{N}{m^2} m^2}{m} [N/m]$, $\alpha \Delta T = 10^{-5} \frac{1}{K} \cdot 20 K = 2E-4$

$u_T = \alpha \Delta T L = 2E-4(1) = 2E-4 \text{ m}$

$f_T = k_q u_T = 2E9 \frac{N}{m}(2E-4 \text{ m}) = \boxed{400,000 \text{ N} = 400 \text{ kN}}$