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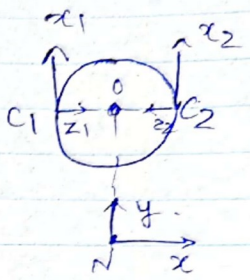
RBE 450X Homework - 1

Part - 1

a) G_1^T calculation

Object dia = 0.03m ⇒ radius = 0.015m

$(C_1 - O) = \begin{bmatrix} -0.015 & 0 & 0 \end{bmatrix}^T$



$$(S(C_1-O)) = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0.015 \\ 0 & -0.015 & 0 \end{bmatrix}$$

$$(S(C_1-O))^T = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -0.015 \\ 0 & 0.015 & 0 \end{bmatrix}$$

$$R_N^{C_1} = \begin{bmatrix} \hat{n} & \hat{t} & \hat{o} \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} \Rightarrow \bar{R}_N^{C_1} = \begin{bmatrix} R_N^{C_1} & 0 \\ 0 & R_N^{C_1} \end{bmatrix}$$

$$\bar{R}_N^{C_1} = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$$P_1 = \begin{bmatrix} I_{3\times3} & (S(C_1-O))^T \\ 0 & I_{3\times3} \end{bmatrix}$$

$$\text{and} \quad G_1^T = \bar{R}_N^{C_1} P_1$$

G_2^T Calculation

$$(C_2 - 0) = \begin{bmatrix} 0.015 & 0 & 0 \end{bmatrix}^T$$

$$(S(C_2 - 0))^T = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0.015 \\ 0 & -0.015 & 0 \end{bmatrix}$$

$$R_N^{C_2} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & -1 \\ -1 & 0 & 0 \end{bmatrix} \Rightarrow \bar{R}_N^{C_2} = \begin{bmatrix} R_N^{C_2} & 0 \\ 0 & R_N^{C_2} \end{bmatrix}$$

$$\bar{R}_N^{C_2} = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 \\ 0 & 0 & 0 & -1 & 0 & 0 \end{bmatrix}$$

$$P_2 = \begin{bmatrix} I_{3\times3} & (S(C_1 - 0))^T \\ 0 & I_{3\times3} \end{bmatrix}$$

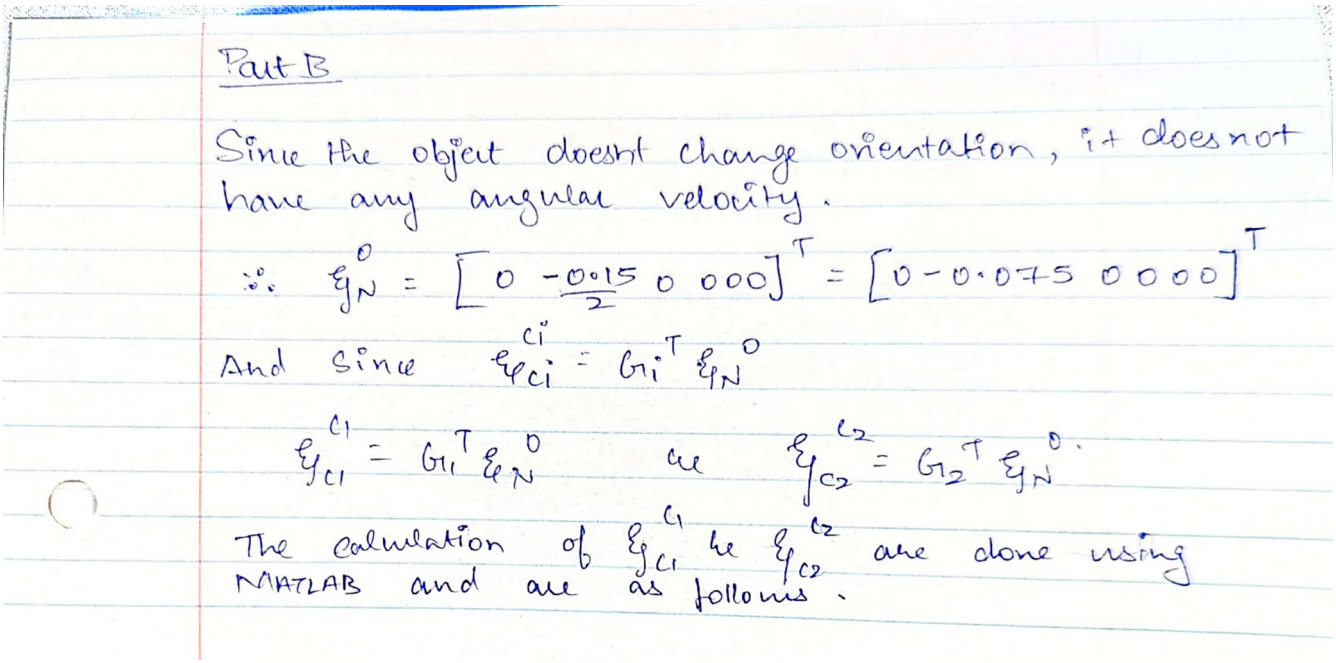
$$\text{i.e. } G_2^T = \bar{R}_N^{C_2} P_2.$$

$$G_1^T = \begin{bmatrix} G_1^T \\ G_2^T \end{bmatrix}$$

The Calculation for P_1, P_2, G_1^T, G_2^T & G_1^T are performed using matlab & the results are as follows.

```
 >> skew1 = [0 0 0; 0 0 -0.015; 0 0.015 0]

skew1 =

         0         0         0
         0         0   -0.0150
         0    0.0150         0

>> rnc1 = [0 1 0; 0 0 1; 1 0 0]

rnc1 =

     0     1     0
     0     0     1
     1     0     0

>> rnc1bar = [rnc1 zeros(3); zeros(3) rnc1]

rnc1bar =

     0     1     0     0     0     0
     0     0     1     0     0     0
     1     0     0     0     0     0
     0     0     0     0     1     0
     0     0     0     0     0     1
     0     0     0     1     0     0

>> P1 = [eye(3) skew1; zeros(3) eye(3)]

P1 =

    1.0000         0         0         0         0         0
         0    1.0000         0         0         0   -0.0150
         0         0    1.0000         0    0.0150         0
         0         0         0    1.0000         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0    1.0000

>> G1 = rnc1bar*P1

G1 =

         0    1.0000         0         0         0   -0.0150
         0         0    1.0000         0    0.0150         0
    1.0000         0         0         0         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0    1.0000
         0         0         0    1.0000         0         0

>> skew2 = [0 0 0; 0 0 0.015; 0 -0.015 0]

skew2 =

         0         0         0
         0         0    0.0150
         0   -0.0150         0
```

```
>> rnc2 = [0 1 0; 0 0 -1; -1 0 0]

rnc2 =

     0     1     0
     0     0    -1
    -1     0     0

>> rnc2bar = [rnc2 zeros(3); zeros(3) rnc2]

rnc2bar =

     0     1     0     0     0     0
     0     0    -1     0     0     0
    -1     0     0     0     0     0
     0     0     0     0     1     0
     0     0     0     0     0    -1
     0     0     0    -1     0     0

>> P2 = [eye(3) skew2; zeros(3) eye(3)]

P2 =

    1.0000         0         0         0         0         0
         0    1.0000         0         0         0    0.0150
         0         0    1.0000         0   -0.0150         0
         0         0         0    1.0000         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0    1.0000

>> G2 = rnc2bar*P2

G2 =

         0    1.0000         0         0         0    0.0150
         0         0   -1.0000         0    0.0150         0
   -1.0000         0         0         0         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0   -1.0000
         0         0         0   -1.0000         0         0

>> G = [G1;G2]

G =

         0    1.0000         0         0         0   -0.0150
         0         0    1.0000         0    0.0150         0
    1.0000         0         0         0         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0    1.0000
         0         0         0    1.0000         0         0
         0    1.0000         0         0         0    0.0150
         0         0   -1.0000         0    0.0150         0
   -1.0000         0         0         0         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0   -1.0000
         0         0         0   -1.0000         0         0
```



Part B

Since the object doesn't change orientation, it does not have any angular velocity.

$\therefore \xi_N^0 = \left[0 \ -\frac{0.15}{2} \ 0 \ 0 \ 0 \ 0\right]^T = \left[0 \ -0.075 \ 0 \ 0 \ 0 \ 0\right]^T$

And since $\xi_{ci}^{ci} = G_i^T \xi_N^0$

$\xi_{c1}^{c1} = G_1^T \xi_N^0$ & $\xi_{c2}^{c2} = G_2^T \xi_N^0$.

The calculation of ξ_{c1}^{c1} & ξ_{c2}^{c2} are done using MATLAB and are as follows.

```
>> newtwist = transpose([0 -0.075 0 0 0 0])

newtwist =

         0
   -0.0750
         0
         0
         0
         0

>> twistc1toc1 = G1*newtwist

twistc1toc1 =

   -0.0750
         0
         0
         0
         0
         0

>> twistc2toc2 = G2*newtwist

twistc2toc2 =

   -0.0750
         0
         0
         0
         0
         0
```

PART - B


gs@gs: ~/rbe450x-ros 61x11
gs@gs:~/rbe450x-ros$. install/setup.bash
gs@gs:~/rbe450x-ros$ ros2 run sum_of_vectors service
[INFO] [1663305899.735937724] [minimal_service]: Incoming req
uest
a: [1 1 1] b: [2 2 2]
[INFO] [1663305941.139586219] [minimal_service]: Incoming req
uest
a: [-10 15 -55] b: [20 2 29]
gs@gs: ~/rbe450x-ros 67x11
gs@gs:~/rbe450x-ros$ ros2 run sum_of_vectors client 1,1,1 2,2,2
[INFO] [1663305899.749965403] [minimal_client_async]: Result of add
_two_vectors: for [1 1 1] + [2 2 2] = [3 3 3]
gs@gs:~/rbe450x-ros$ ros2 run sum_of_vectors client -10,15,-55 20,2
,29
[INFO] [1663305941.151064450] [minimal_client_async]: Result of add
_two_vectors: for [-10 15 -55] + [20 2 29] = [10 17 -26]
gs@gs:~/rbe450x-ros$