Table of Contents


```
clc;
clear;
```

Some Functions

```
Weighting_func = @(m_vec,x_vec) (x_vec*m_vec')./sum(m_vec);

AngMom_func = @(m_vec,r_vec,v_vec,rcom) ...
    [ ((r_vec(2,:)-rcom(2)).*v_vec(3,:) - (r_vec(3,:)-
rcom(3)).*v_vec(2,:)) *m_vec' ; ...
      ((r_vec(3,:)-rcom(3)).*v_vec(1,:) - (r_vec(1,:)-
rcom(1)).*v_vec(3,:)) *m_vec' ; ...
      ((r_vec(1,:)-rcom(1)).*v_vec(2,:) - (r_vec(2,:)-
rcom(2)).*v_vec(1,:)) *m_vec' ];
```

Checking with data set at time t0

```
load mrvdata0_2019

Mtot = sum(mvec);
rcm0 = Weighting_func(mvec,rmat0);
vcm0 = Weighting_func(mvec,vmat0);
ptot0 = vcm0.*Mtot;
h0  = AngMom_func(mvec,rmat0,vmat0,rcm0);

rcm0_c =[ 4.135068659460397; 4.232438883625573; -2.649670988093459];
ptot0_c =[ -3.304955397587092; 2.615681258483552;
 -12.378512402556995];
vcm0_c =[ -0.448630861116144; 0.355065407616567; -1.680320007510681];
h0_c =[ 0.158538578051034; -0.117644152647727; -0.423922316388524];


format long
disp('Errors are:')
disp('Center of mass')
disp(norm(rcm0-rcm0_c))
disp('Total momentum')
disp(norm(ptot0-ptot0_c))
disp('Velocity of center of mass')
disp(norm(vcm0-vcm0_c))
disp('Angular velocity about center of mass')
```

```
disp(norm(h0-h0_c))
```

```
Errors are:
Center of mass
     1.256073966947020e-15

Total momentum
     1.831026719408895e-15

Velocity of center of mass
     5.926969055564841e-16

Angular velocity about center of mass
     1.509301780344530e-14
```

Solution for data set at time t1

```
load mrvdata1_2019

rcm1 = Weighting_func(mvec,rmat1);
vcm1 = Weighting_func(mvec,vmat1);
ptot1 = vcm1.*Mtot;
h1  = AngMom_func(mvec,rmat1,vmat1,rcm1);


disp('Solution for Data set at t1:')
disp('Center of mass')
disp(rcm1')
disp('Total momentum')
disp(vcm1')
disp('Velocity of center of mass')
disp(ptot1')
disp('Angular velocity about center of mass')
disp(h1')
```

```
Solution for Data set at t1:
Center of mass
   6.496750220923424   6.436764329727224  -3.950000393183263

Total momentum
   0.176454273684443   0.192731693478986  -1.278640574034888

Velocity of center of mass
   1.299896094508161   1.419807921962311  -9.419436853311913

Angular velocity about center of mass
   0.254661038188203  -0.435851676485561  -0.666628074221855
```

Forces and Moments

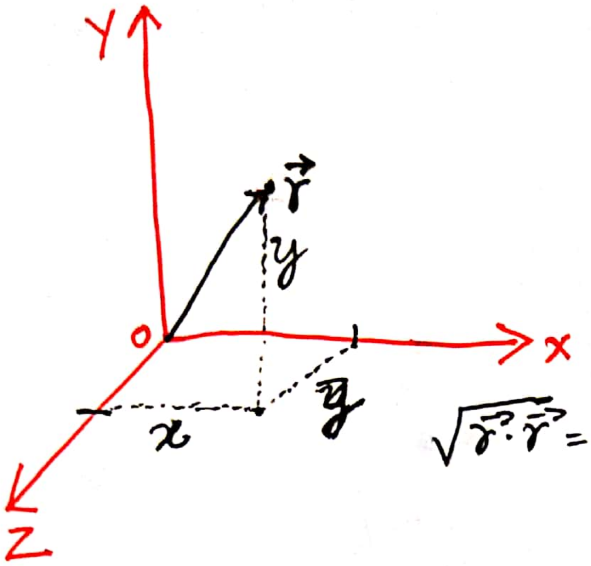
```
dt = t1 - t0;
```

```
Fexttotavg = (ptot1 - ptot0)./dt;

Texttotavg = (h1 - h0)./dt;

disp('Solution for Forces and Moments:')
disp('Total average exteral forces')
disp(Fexttotavg')
disp('Total average exteral moments')
disp(Texttotavg')
```

```
Solution for Forces and Moments:
Total average exteral forces
   8.672036708277311  -2.252115511339435   5.572646985395630

Total average exteral moments
   0.181021582179245  -0.599260873517558  -0.457072990269928
```

Published with MATLAB® R2017a

3)



$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

Then

$$|\vec{r}| = \sqrt{(x-0)^2 + (y-0)^2 + (z-0)^2}$$

$$\sqrt{\vec{r}\cdot\vec{r}} = \sqrt{|\vec{r}|^2 \cos(0)} = \sqrt{x^2 + y^2 + z^2} \quad \blacksquare$$

4) let,

$$\vec{r}^{\,b} = \begin{bmatrix} x^b \\ y^b \\ z^b \end{bmatrix} \quad \& \quad \vec{r}^{\,a} = \begin{bmatrix} x^a \\ y^a \\ z^a \end{bmatrix}$$

are the Comp-onent written in a Column vector form.

Then

$$\sqrt{(x^a)^2 + (y^a)^2 + (z^a)^2} = \sqrt{\vec{r}^{\,a}\cdot\vec{r}^{\,a}}$$

from the previous Result

Similarly

$$\sqrt{(x^b)^2 + (y^b)^2 + (z^b)^2} = \sqrt{\vec{r}^{\,b}\cdot\vec{r}^{\,b}}$$

Given the Relation we can write following from what is given in the question 4.

$$\sqrt{\vec{r}^{\,b}\cdot\vec{r}^{\,b}} = \sqrt{[x^b \;\; y^b \;\; z^b]\begin{bmatrix} x^b \\ y^b \\ z^b \end{bmatrix}} = \sqrt{(R^{ba}\vec{r}^{\,a})^T(R^{ba}\vec{r}^{\,a})}$$

$$= \sqrt{\vec{r}^{\,a\,T} R^{ba\,T} R^{ba} \vec{r}^{\,a}}$$

from the property of the Orthonormality of R^{ba}

$$R^{ba^T} = R^{ba^{-1}}$$

$$\therefore R^{ba^T} R^{ba} = I_{3\times3}$$

$$\therefore \sqrt{\vec{r}^{\,b} \cdot \vec{r}^{\,b}} = \sqrt{\vec{r}^{\,a^T} \vec{r}^{\,a}} = \sqrt{\begin{bmatrix} x^a & y^a & z^a \end{bmatrix} \begin{bmatrix} x^a \\ y^a \\ z^a \end{bmatrix}}$$

$$= \sqrt{(x^a)^2 + (y^a)^2 + (z^a)^2}$$

$\therefore$

$$\sqrt{(x^b)^2 + (y^b)^2 + (z^b)^2} = \sqrt{(x^a)^2 + (y^a)^2 + (z^a)^2} \quad \blacksquare$$