Where:

Simplifying the equations, we have the equation of motion for (x, y, z) components:

For z component:

Let’s use ansatz,

where is just a free parameter, is an initial angular offset parameter and and we need to also make sure . We check for this condition in the software. Since is always positive, we just need to make sure that when we set the parameter, has the same sign as .

Then,

For x and y components:

Let’s use ansatz,

where and are just free parameters and solving for

In the software, we need to make sure so that we don’t have complex and we can choose or .

We get when and therefore it is purely cyclotron motion and no motion in z direction.

In the software, to make sure that condition 2 hold, we can refer to the following where we simplified condition 2 further:

The forces are then:

In the software, we can opt for force visualisation for component (x, y, z). To moderate the length of arrows shown in force visualisation, we further scale the maximum value of force to a quarter of its unit length and then scale proportionally to the scale of the axes so that the force is always visible when the axes are scaled.

Where and nominal axis length is absolute value of parameter , and for x, y, and z components respectively.

Example Parameter Settings in Matlab command window:

Enter "d" in metre:1

Enter "B\_0" in Tesla:5

Enter "q\_0" in Coulomb:1

Enter "m" in kg:1

Enter "V\_0" in Volt:2

Enter "A1" for x amplitude:1

Enter "A2" for y amplitude:1

Enter "B" for z amplitude:1

Enter "phi\_z" for z initial offset angle in radian:0

Enter "phi\_a" for azimuthal initial offset angle in radian:0

Choose w\_c+ (0) or w\_c- (1):0

Enter total number of frame for simulation:2000

Enter time t in second for simulation:35

Visualise force? Yes(1) No(0):0

**References**

1. Gabrielse.physics.harvard.edu. 2018 [accessed 2018 Apr 21]. <http://gabrielse.physics.harvard.edu/gabrielse/papers/1990/1990_tjoelker/chapter_2.pdf>
2. MATLAB Answers - MATLAB Central. Mathworks.com. 2018 [accessed 2018 Apr 21]. https://www.mathworks.com/matlabcentral/answers