LEARNING DYNAMICS AND VIBRATIONS BY ADAMS SOFTWARE

By:

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Introduction:

ADAMS (Automatic Dynamic Analysis of Mechanical Systems) is a powerful software for modeling and analyzing of the dynamics and vibration of complex mechanisms. Its development started in 1974 at the University of Michigan; and now the software is using by many large industries. It uses Lagrange method to create equations of motion. The software has Powerful parametric, scripting and post-processing abilities; and its integrated animation and plotting helps thorough analyses of a multi-body dynamics and vibrations of a mechanical system.

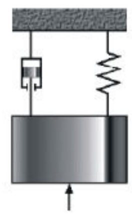
This tutorial is intended to provide some basic experience with ADAMS for modeling simple systems. (ADAMS Version 2013).After taking this class, you should be: (i) Familiar with Adams terminology (ii) Able to build models of moderate complexity (iii) Comfortable with the various input/output files (iv) Aware of the different simulation types in Adams (v) Able to effectively post-process information, creating plots, animations and reports (vi)Familiar with function expressions, constraints and the other 'building block' elements in Adams.

The particular objective of this tutorial (designed as a complementary part for **UBC MECH 463**, Mechanical Vibrations) is to review the fundamental of mechanical vibrations by conducting some simple simulations of mass-spring-damping system, free and force vibrations, unbalance rotating systems; and design of vibration absorber.

Single DOF Mass-Spring-Damping System

Problem Description

We will be modeling a single DOF spring-mass-damper system. In this case, ***M = 10 kg, k = 1 N/mm*** and ***c = 0.01 Ns/mm***.



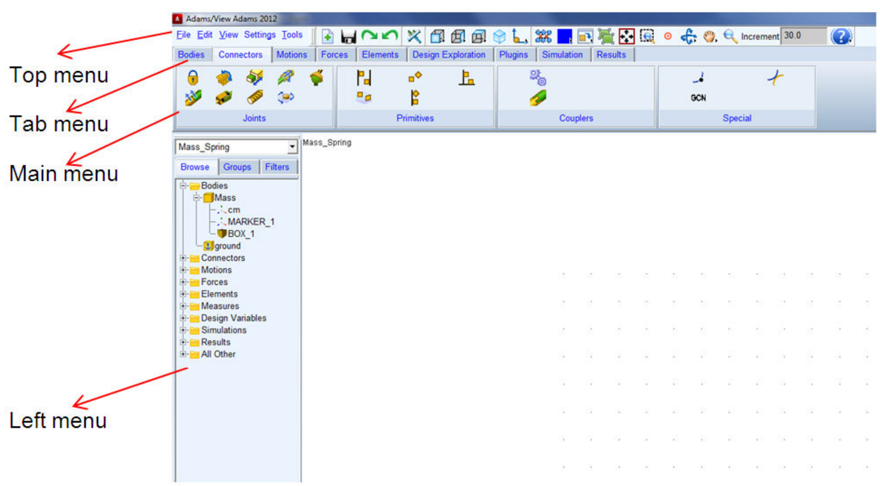
Starting ADAMS:

1- Create a New Folder *(with a name, so you know where you are saving your files, for your future reference)*.

2- Launch ADAMS/View (Start menu/ Programs/MSC.Software/Adams/Aview/ADAMS.

3- Choose New Model, Select your target folder, and give a name to your model.

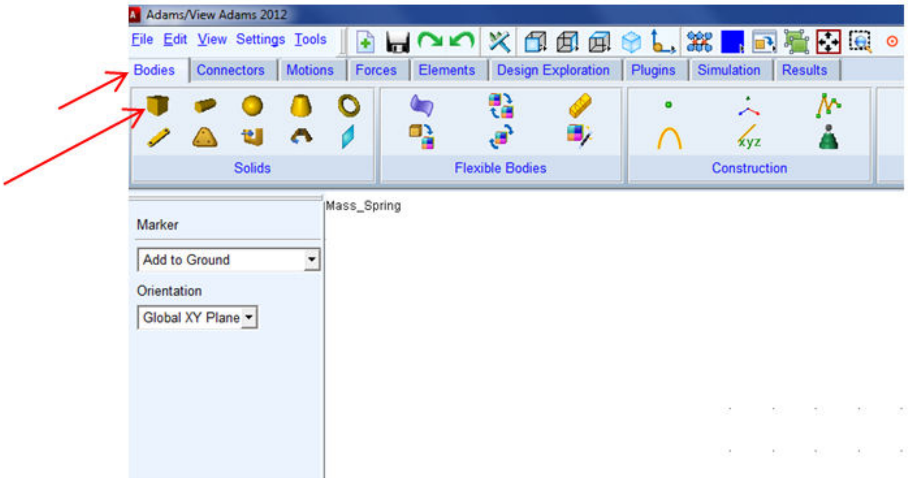
4- From top menu/settings/ coordinate, select your desire coordinate (default is Cartesian).



5- From top menu/settings/ units, select your desire units.

6- Verify the Gravity(the direction).

7- Create a Block: choose Tab menu/Bodies, and select Box (use mouse, hold left click, drag and release with arbitrary size)



8- Right click on the block/Part, and change its name to “Mass”.

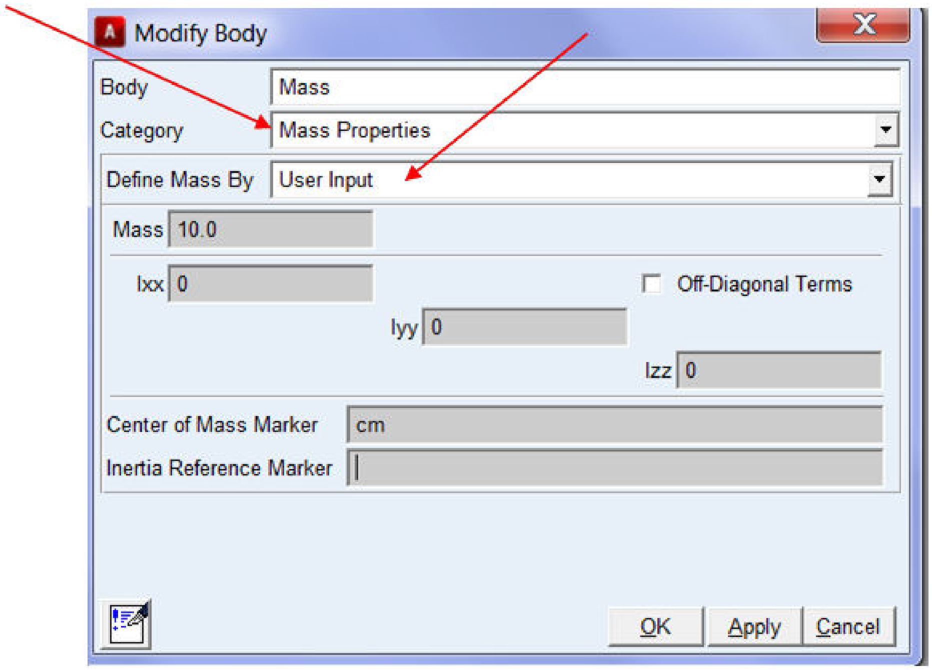
9- Right click on the block/Box, and modify its length, height, and width (200,100,100mm).

10- From left menu/Bodies/Mass, right click on Marker_1 and modify it to (-100,-50,-50) (if your chosen units is mm).

(ThisMarker is the corner of the Box, and we modify it so that the center of the block be at 0,0,0).

11- Check the cm (center of mass). Is it at the origin?

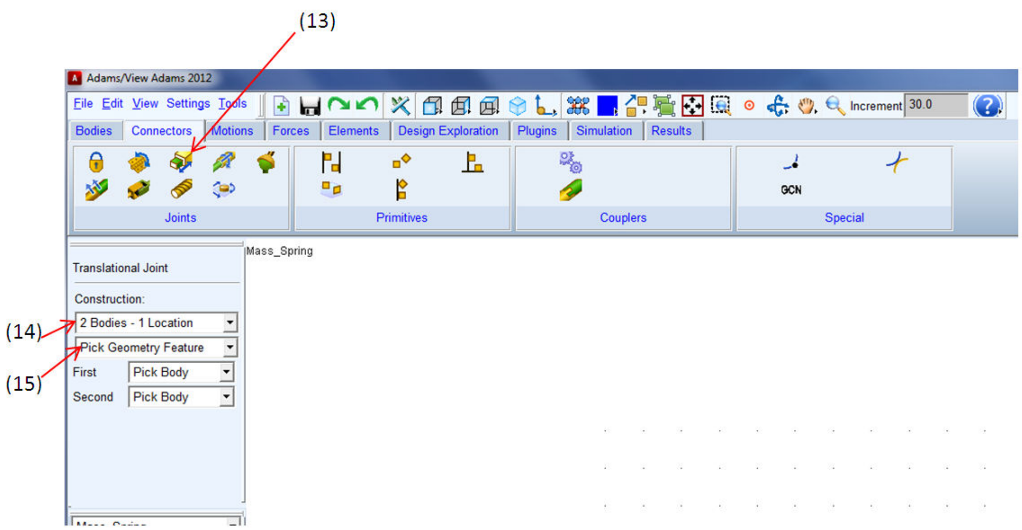
12- Right click on the created block, and choose Part: Mass/Modify ; then choose “Mass Properties”; and “User Input”. Let mass be 10 Kg and all moment of inertia 0 (why?).



13- From Tab menu select: “Connectors” then select “Translational Joint”.

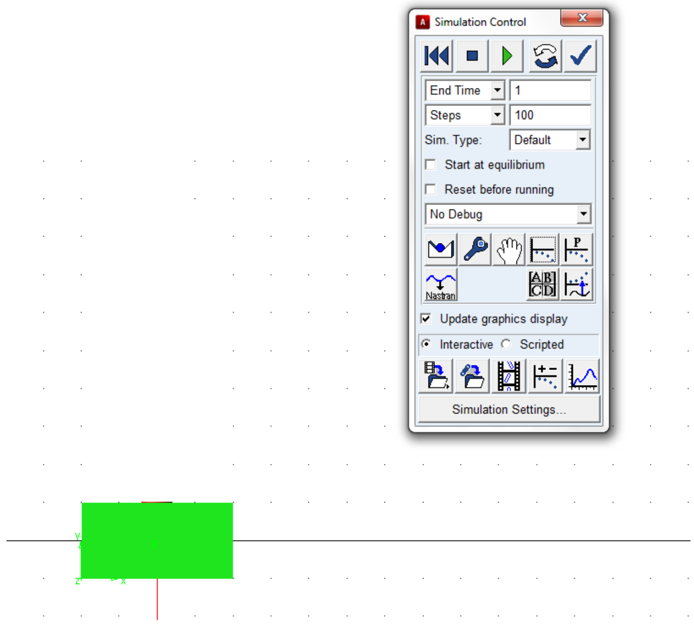
14- Select “1 Bodies-1 Location”.

15- Select “Pick Geometry Feature”.

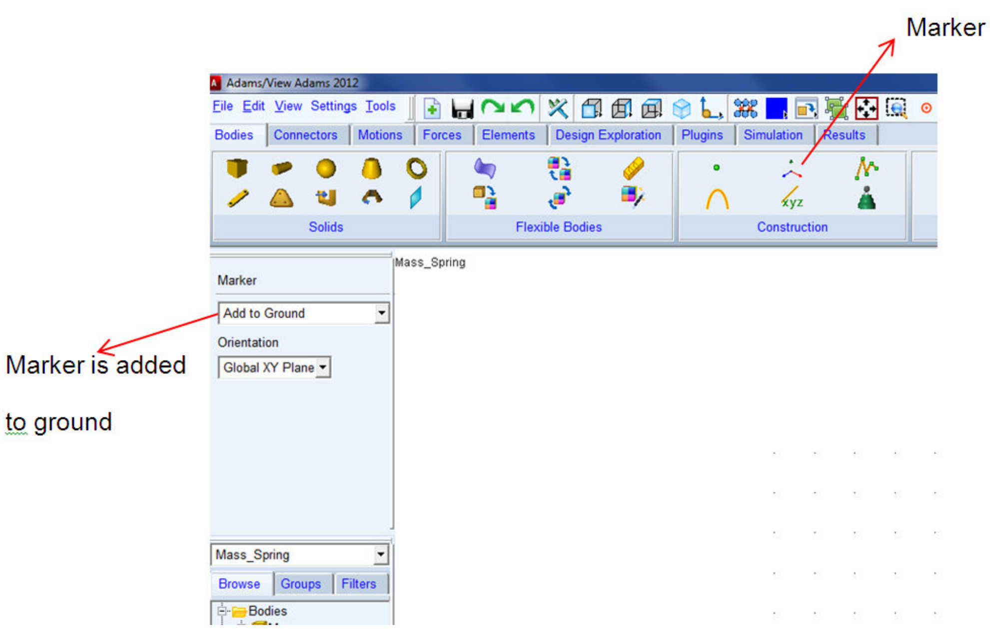


16- Select the Mass, then click on the ground, and then select the “Mass.cm”, and choose the direction vector.

17- Run a Simulation: 1 sec, and 100 steps (what does happen?).



18- From Tab menu select Bodies, then from main menu select “marker”; (add to Ground) then right click somewhere on the Grid, and write the location:(0,400,0)



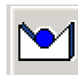
19- From Tab menu, select “Force” and then select “Spring”

20- Select the Mass.cm, then select the ground.marker (the one you just created)

21- Right click on the spring, and choose "Modify" then let stiffness to be 1N/mm (or 1000N/m);

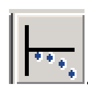
Damping=0; Pre-load = 0

22- Find Equilibrium Position

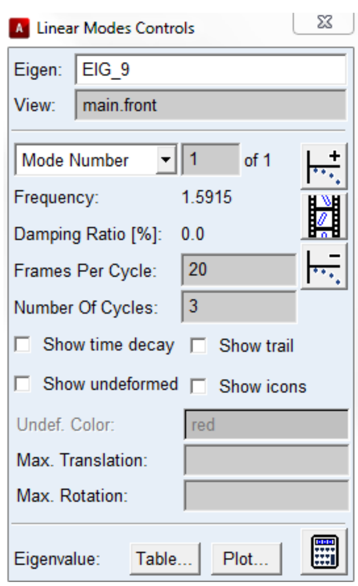
Click on the Find Static Equilibrium icon  in the Simulation Control Toolbox.

23- Linear Systems Analysis

ADAMS has the power to linearize complex models about an operating point (defined by the position the model is displayed on the screen) and then perform an eigenvalue analysis. This can be extremely useful for investigating the stability of a system, or validating calculations done using some other software.

First: Click on the **Compute Linear Modes** icon, .

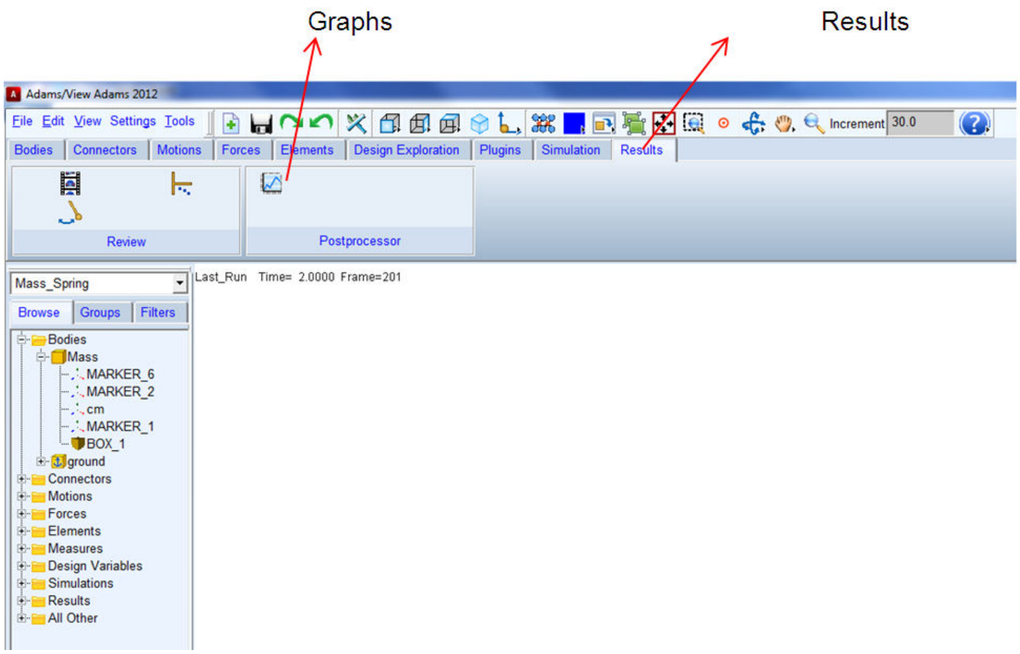
Second: Click '**Animate**' when ADAMS prompts you to view results of the Linear Mode analysis. The **Linear Modes Control Toolbox** Appears



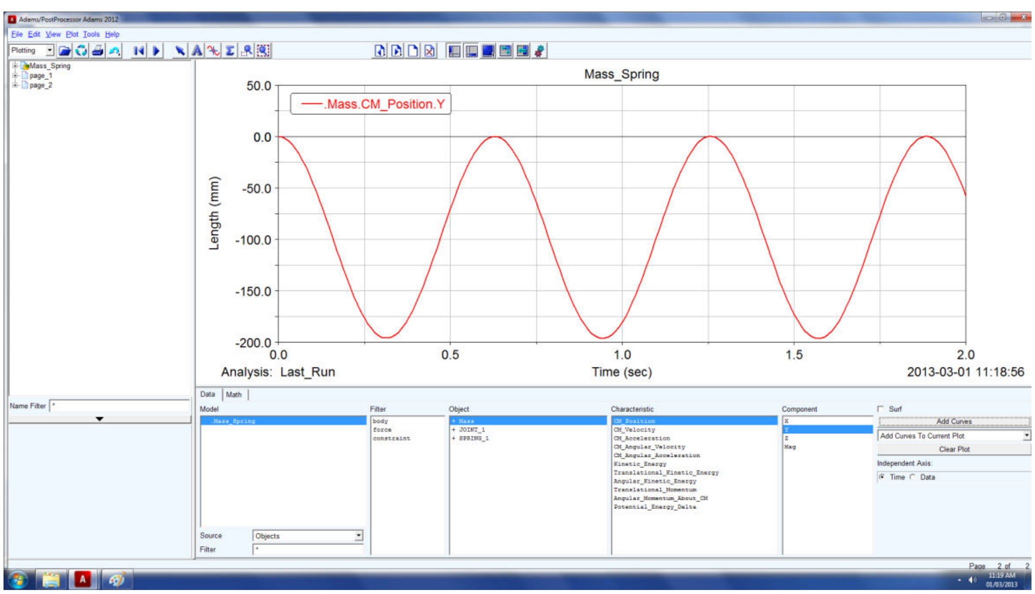
What is the natural frequency? (Compare it with your hand calculation: $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$)

24- Run a simulation: 2Sec, with 200 steps

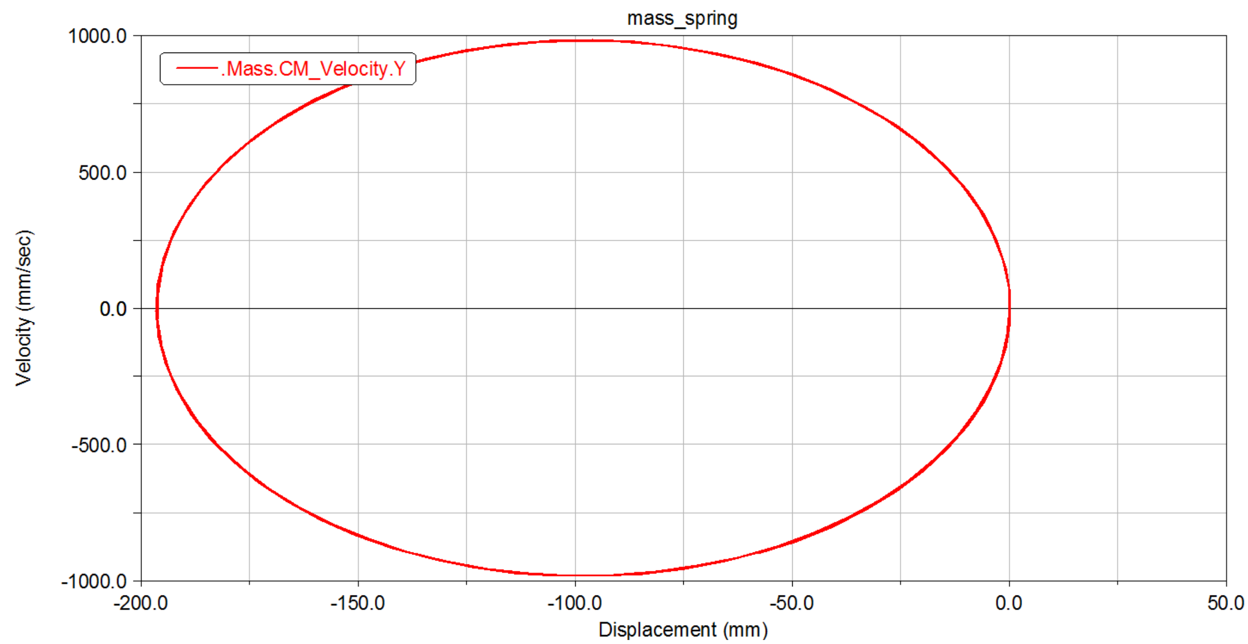
25- From Tab menu select “Results”; then from main menu select “Postprocessor”



26- Produce the Mass.cm position graph in Y direction. (You can produce other graphs like, cm_velocity, Kinetic Energy, …)

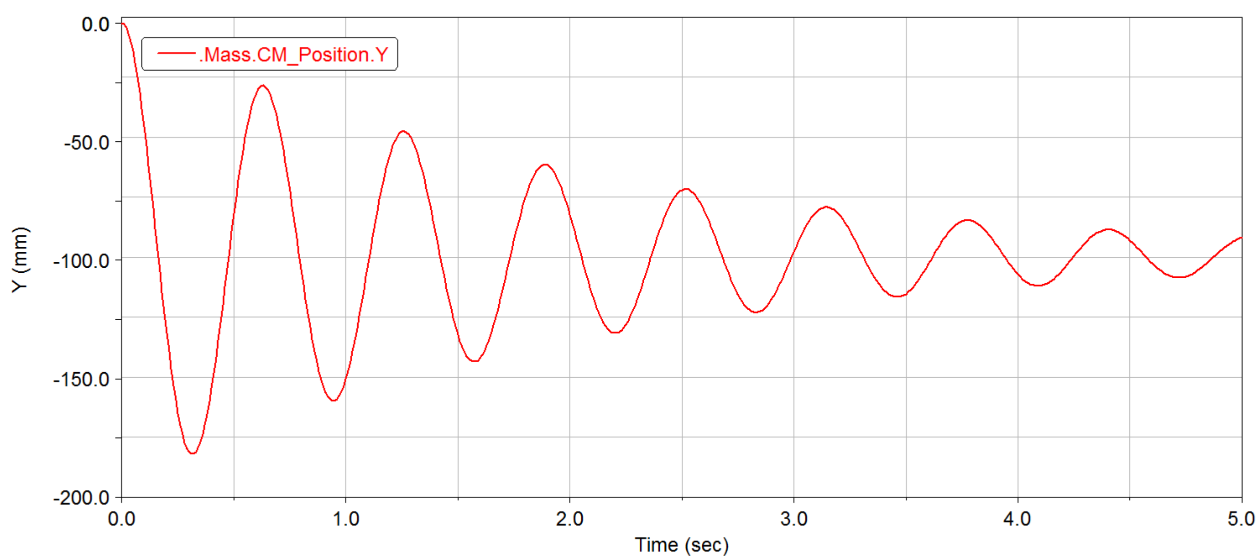


27- Produce a graph that shows variation of cm.velocity as function of cm.position (load animation and observe the behaviour)**(Phase Plane)**

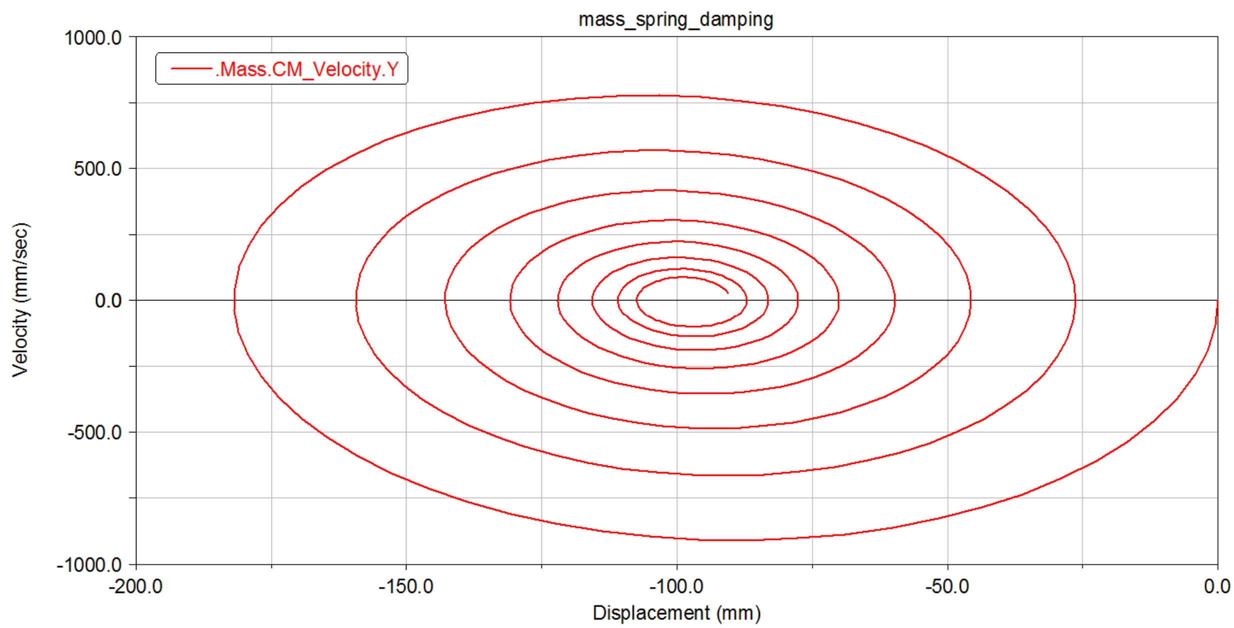


28- Choose damping =0.01 (N.sec/mm); and Run a simulation: 5Sec, with 500 steps

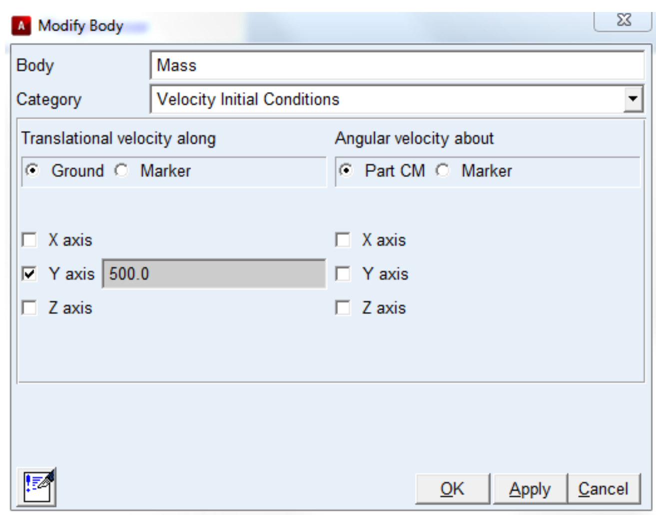
29- Produce the Mass.cm position graph in Y direction.



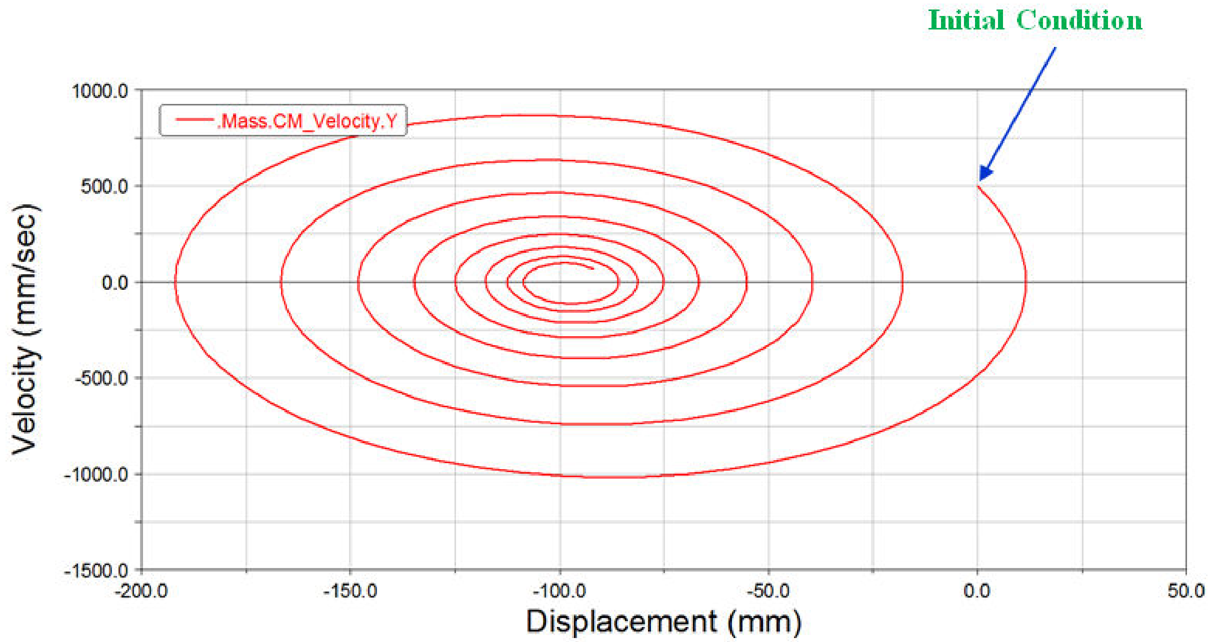
30- Produce a graph that shows variation of cm.velocity as function of cm.position (load animation and observe the behaviour)(Phase Plane)



31- Right click on the mass, select modify, then from dialog window: Categories, select "Velocity Initial Conditions"; then let the initial velocity of mass be 500 mm/sec

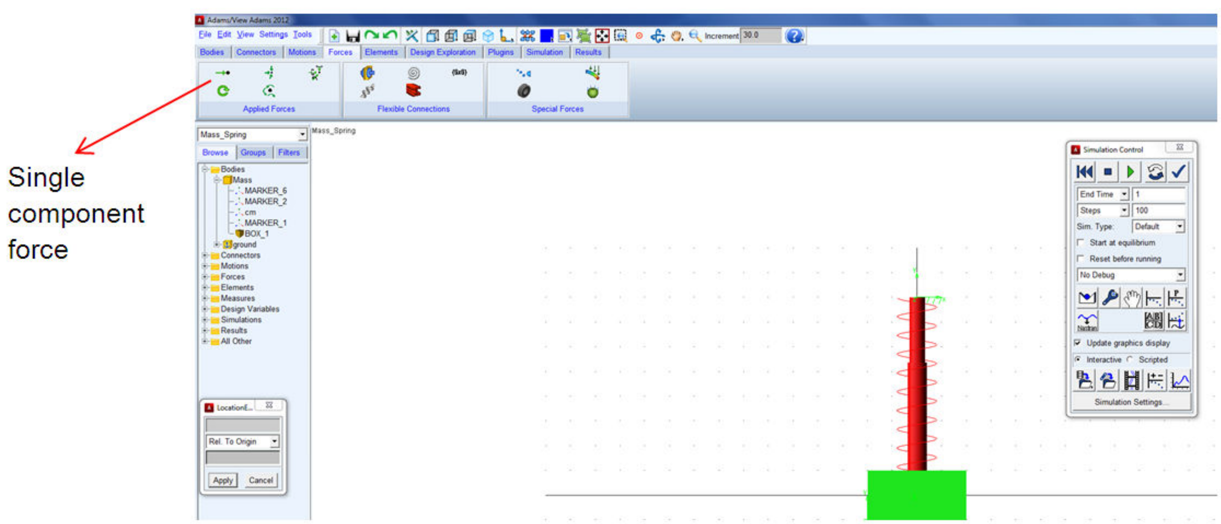


32- Run the simulation (5 sec, 500 steps) and produce the same graph like (procedure 30); investigate the dynamic behaviour.



32- Set the “initial velocity” to be Zero again.

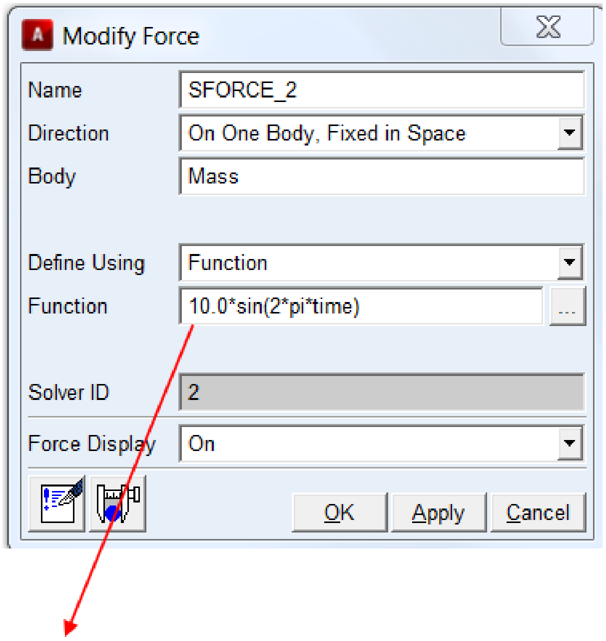
33- From Tab menu/Forces, select “single component force” and then select mass, then select Mass.cm, and direction of force (in –Y direction)



34- Modify the force from Left menu and set it to 10N.

35- Run a simulation and investigate the results (for ex. produce cm.accelaration)

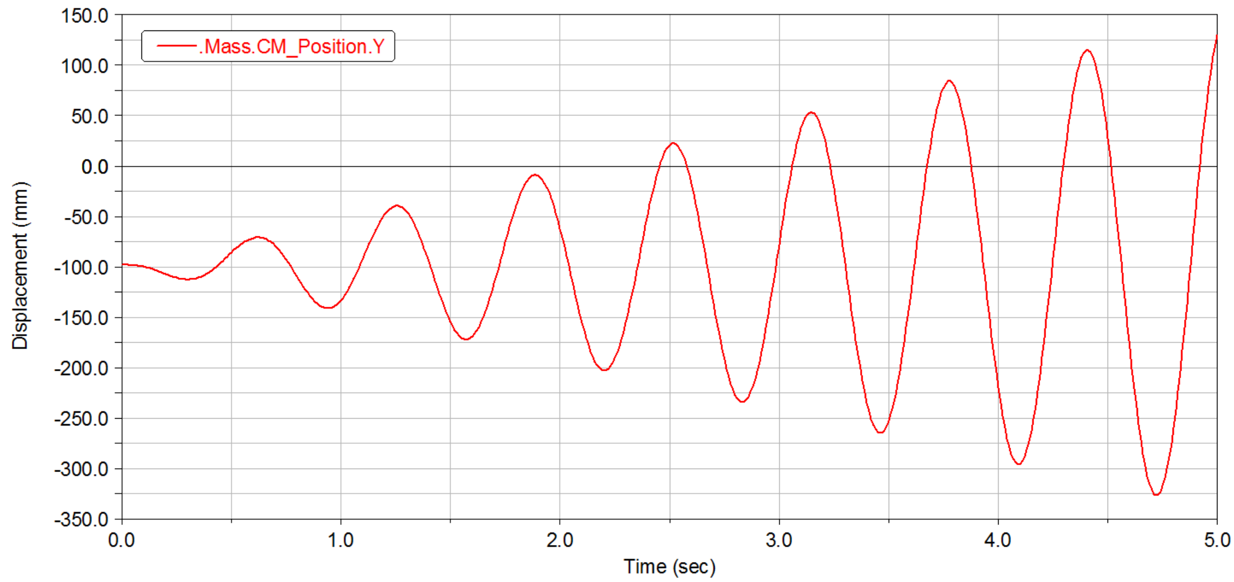
36- Modify the force to $F_0 \sin(2\pi f t)$ (for example: choose $F_0 = 10N$ and $f = 1\ Hz$) observe the transient and steady-state response. (Don't forget to tick "Start from equilibrium" in simulation toolbox)



$10\ sin(2\pi t)$

37- Modify the Spring and set the damping=0

37- Do you remember the natural frequency of the system? (If you forgot, repeat procedure 22, and get the natural frequency)So, choose the frequency of excitation to be f_n. Produce the cm.position graph. (Don't forget to tick "Start from equilibrium")



(Recall from Vibration course, that at $f = f_n$ system experience “resonance”. And at resonance the solution of the differential equation of motion

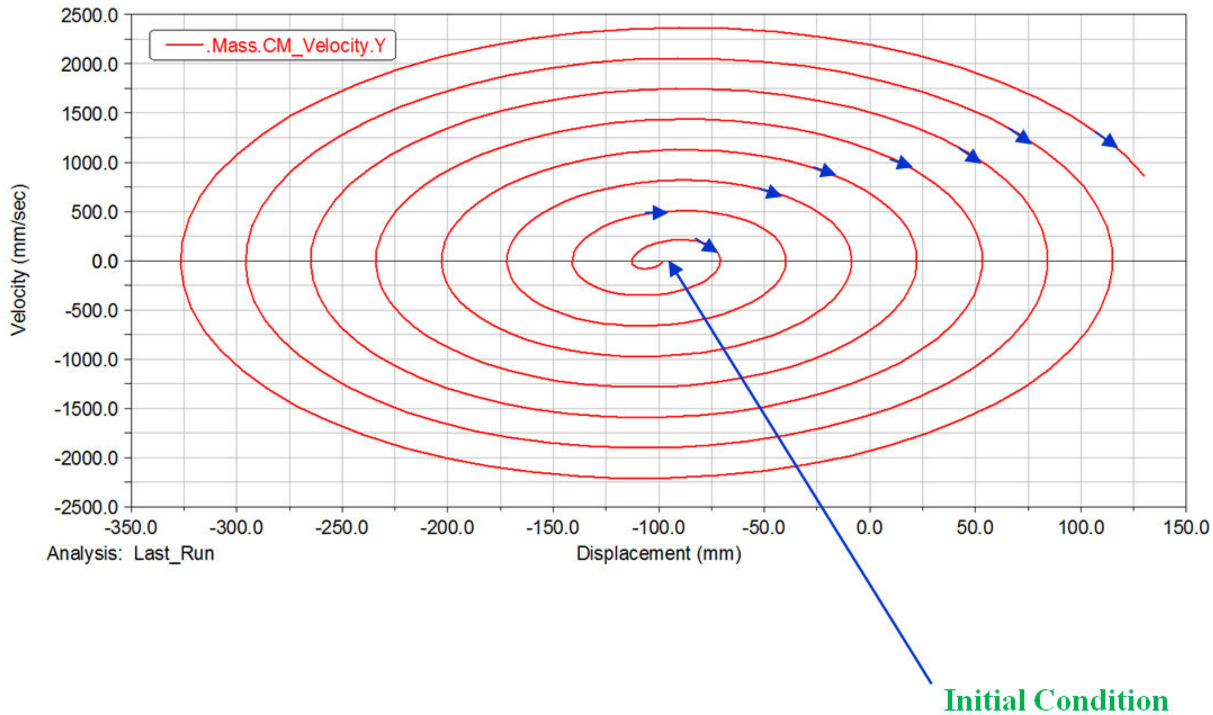
$$(m\ddot{x}(t) + kx(t) = F_0 \sin\,(\omega_n t)\,)$$

has the form

$$\mathrm{x}\,(t) = A\omega_n\, t \cos\,(\omega_n t)$$

(Investigate this for yourself later))

38- Produce phase plane (procedure 30). Load the animation. Observe the behaviour.

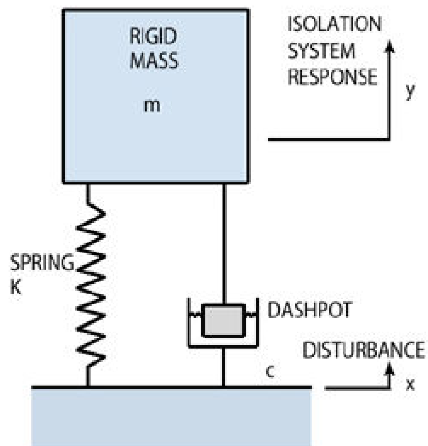


39- Set the damping to be again 0.01

40- Repeat 37 and investigate the results.

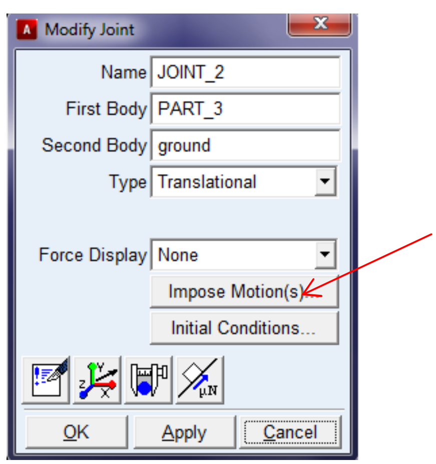
Assignment:

Create the following model (m=10Kg, K=1N/mm, c=0.01N.Sec/mm) And apply a step input to the base. (STEP (time, 0, 0, 0.05, 100)) (Note that these arguments correspond to: time, initial time, initial function value (displacement in this case), final time, and final function value.)



Hint-1: For the base create another box (like the one that you created for the mass); and use a translational connector in Y direction (like procedure 13-15). And then create the spring between the cm.mass and the cm.base.

Hint-2: Right click on the Translational Joint (likely called Joint_2 at this point) that connects the Input part to the Ground and select Modify. A dialogue box appears. Click on the Impose Motion(s) button**.**



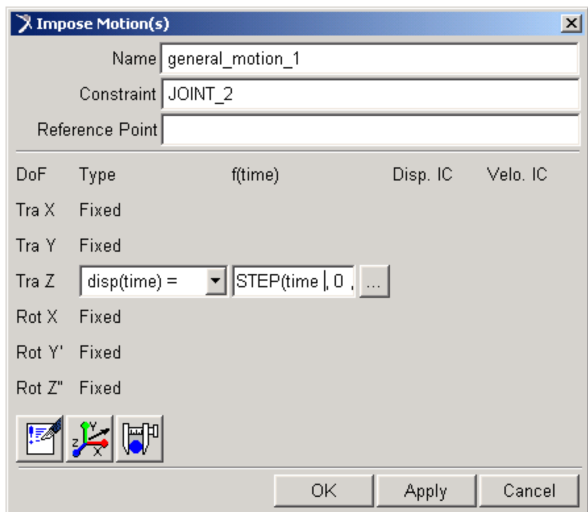
The only direction in which motion can be imposes is Tra Z. Change the motion from free to disp(time) = from the pull-down menu and type the following expression in the window to the right of 'disp(time)=':

STEP(time , 0 , 0 , 0.05 , 100)

Note that these arguments correspond to: time, initial time, initial function value (displacement in this case), final time, and final function value.

This creates a function that starts at zero at time = 0, and ramps to 100 mm at time = 0.05 seconds. It remains at this final value after the final time.

Note: Since the displacement of the road is zero at time = 0, this imposed motion will not affect the calculation of equilibrium positions in ADAMS.



Write a short report and briefly explain the steps you have done to create the model (less than 1 page); and then add the following graphs:

- Displacement and Velocity of the mass in Y direction

- Potential and Kinetic Energy of the mass as a function of time

- Potential and Kinetic Energy of the mass as a function of displacement

Email a PDF file (1 page explanation + 6 Graphs) to ahmadpa20"gmail.com before the start of your next ADAMS class

Vibration of a System with Eccentric Rotating Mass

Problem Description

We will be modeling a single DOF unbalanced rotating system. In this case, ***M = 60 kg***, ***k = 600 N/mm*** and ***c = 0 Ns/mm***. *Unbalance rotating blade* $\boldsymbol{m.e. = 0.03 \times 50\ Kg.mm}$

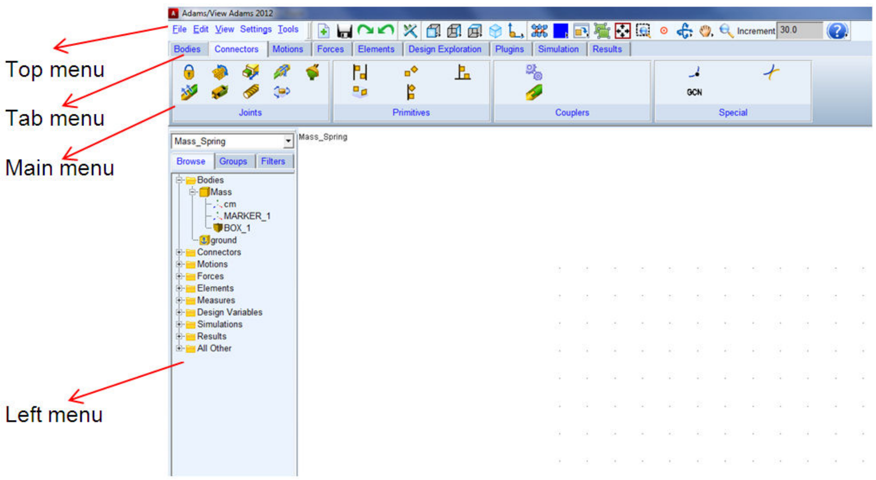
Starting ADAMS:

1- Create a New Folder *(with a name, so you know where you are saving your files, for your future reference)*

2- Launch ADAMS/View (Start menu/ Programs/MSC.Software/Adams/Aview/ADAMS).

3- Choose New Model, Select your target folder, and give a name to your model.

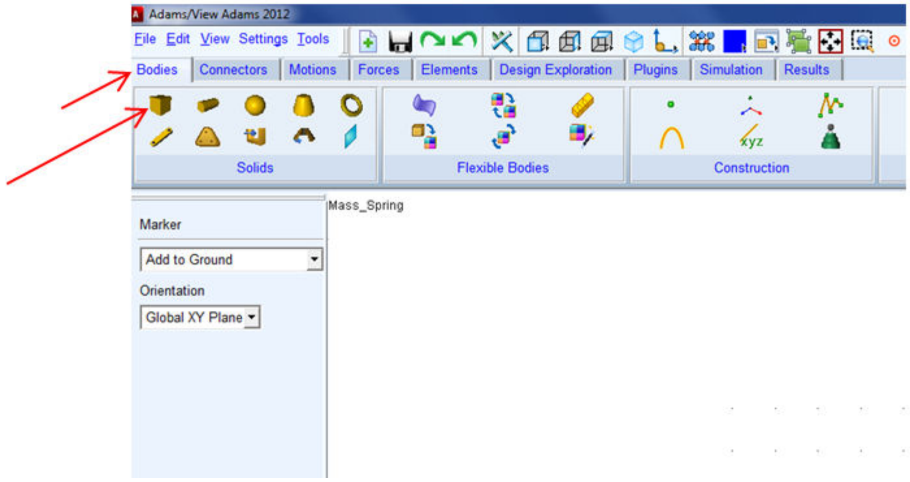
4- From top menu/settings/ coordinate, select your desire coordinate (default is Cartesian).



5- From top menu/settings/ units, select your desire units.

6- Verify the Gravity.

7- Create a Block: choose Tab menu/Bodies, and select Box (use mouse, hold left click, drag and release with arbitrary size)



8- Right click on the block/Part, and change its name to "Frame"

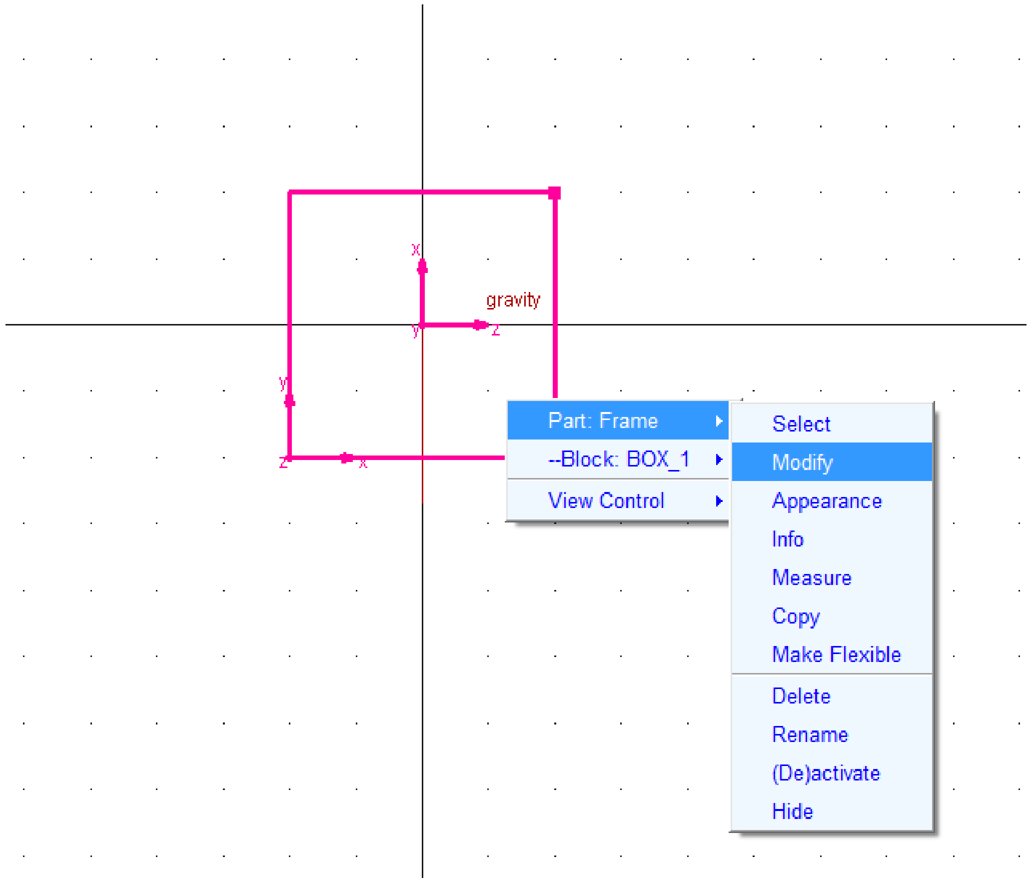
9- Right click on the block/Box, and modify its length, height, and width (200,200,200mm)

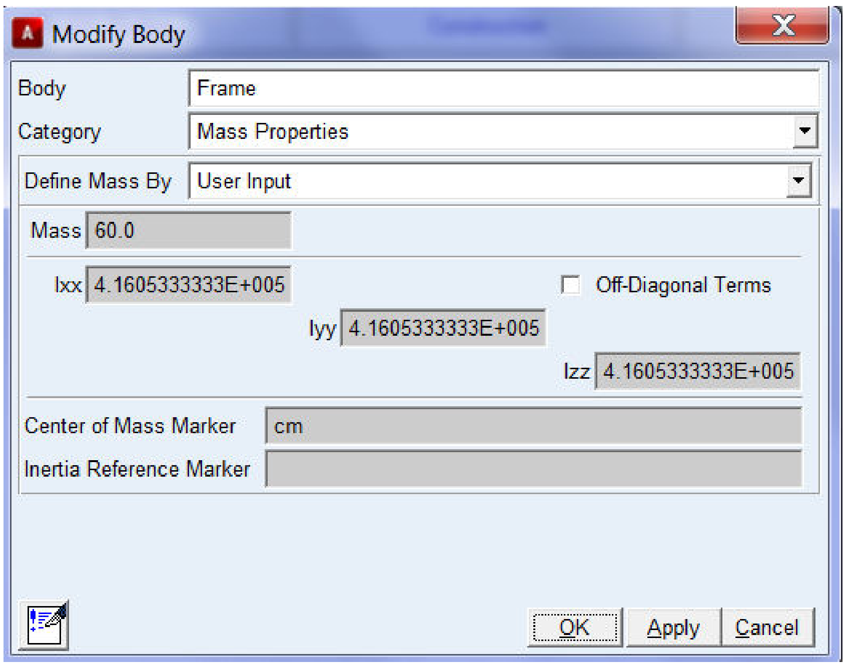
10- From left menu/Bodies/Frame, right click on Marker_1 and modify it to (-100,-100,-100) (if your chosen units is mm)

(This Marker is the corner of the Box, and we modify it so that the center of the block be at 0,0,0)

11- Check the cm (center of mass). is it at the origin?

12- Right click on the created block, and choose Part: Frame/Modify ; then choose "Mass Properties"; and "User Input". Let mass be 60 Kg.

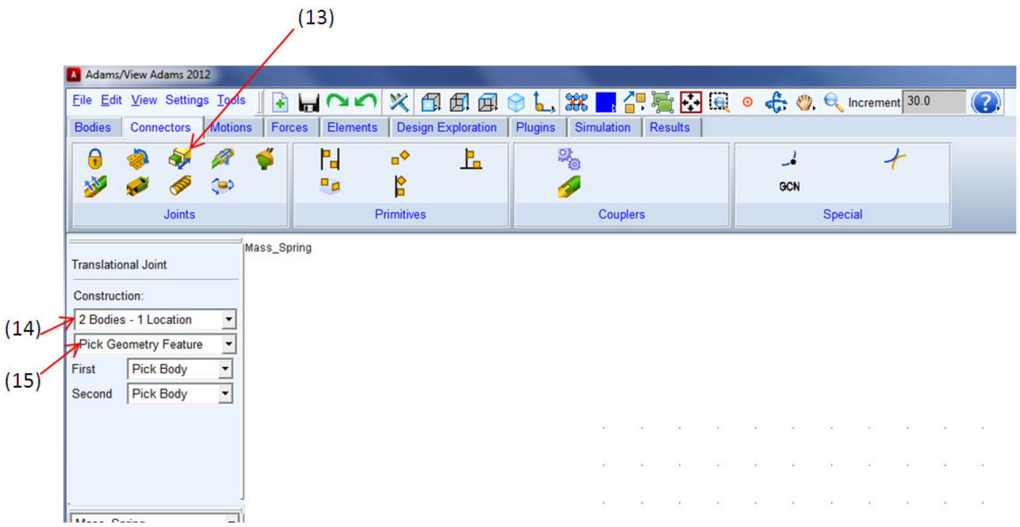




13- From Tab menu select: “Connectors” then select “Translational Joint”

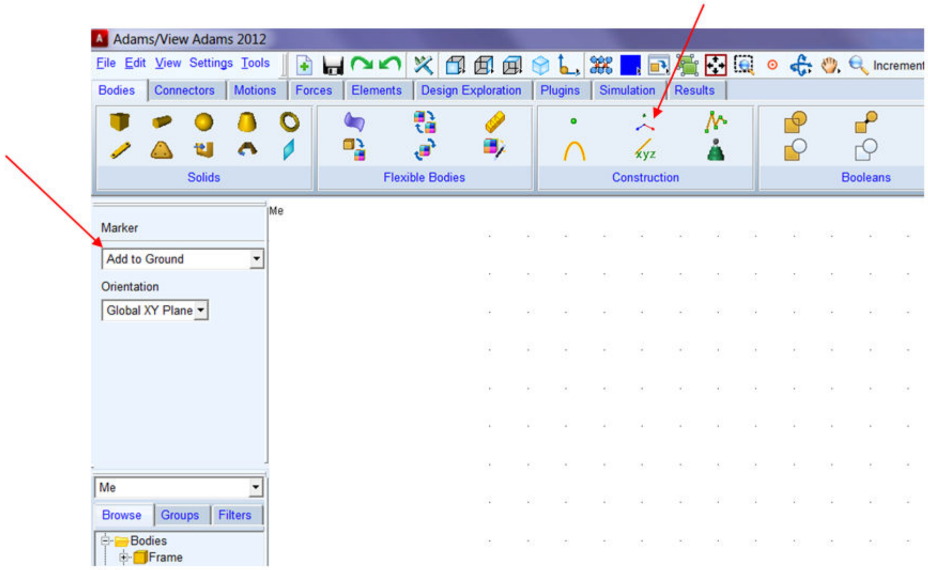
14- Select “1 Bodies-1 Location”

15- Select “Pick Geometry Feature”

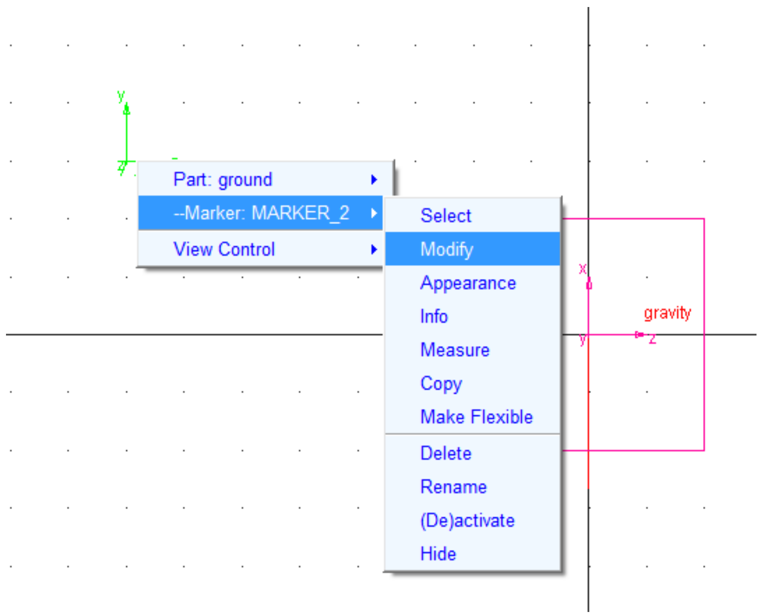


16- Select the Mass, then click on the ground, and then select the “Frame.cm”, and choose the direction vector.

17- From "Top Menu" select "Bodies"; then from "Main Menu" select "Marker". We want this Marker to be attached to the Ground. Click anywhere on the main working window (the Grid area).



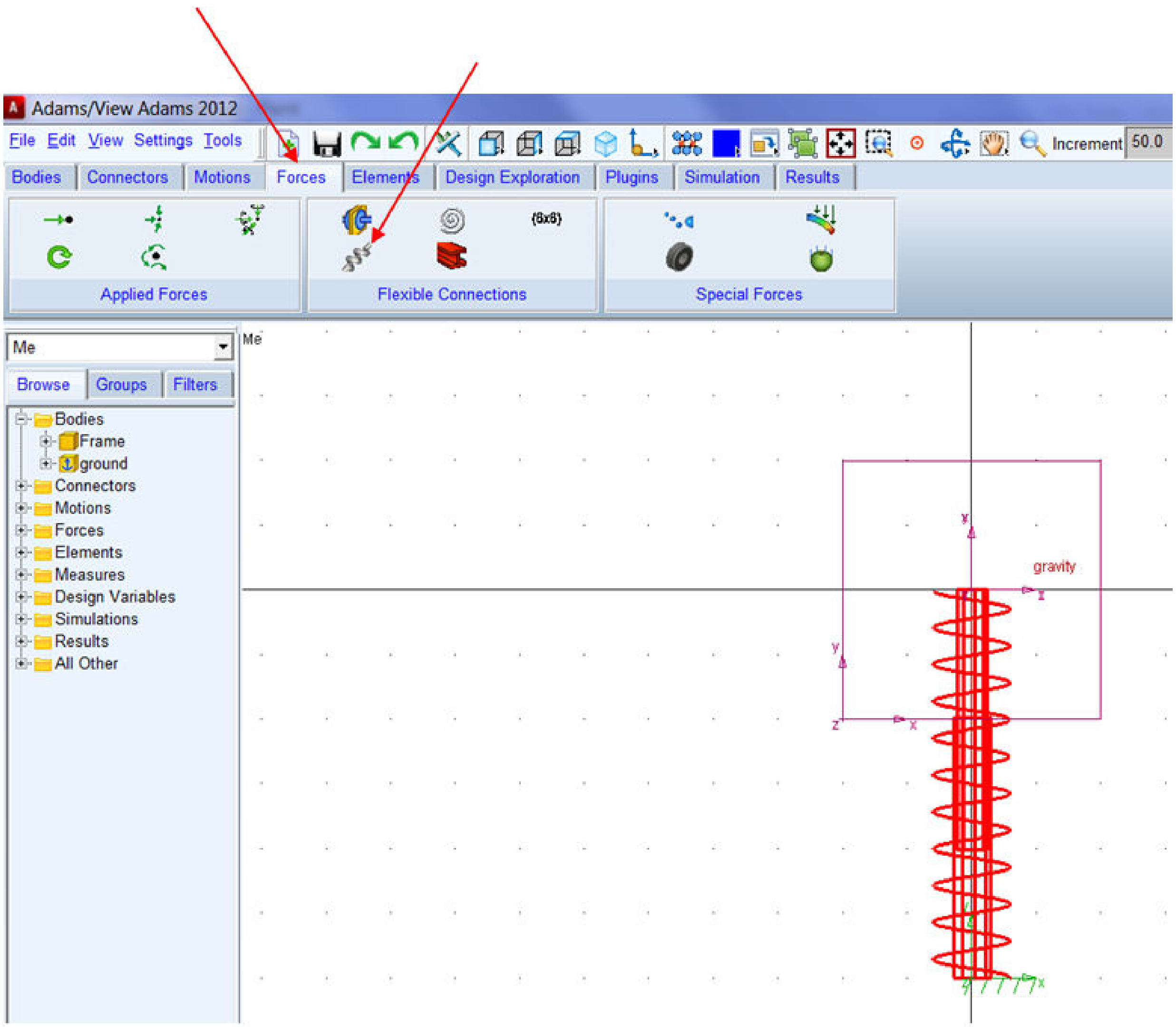
18- Right Click on the Marker you just created; and modify it to (0,-300,0)



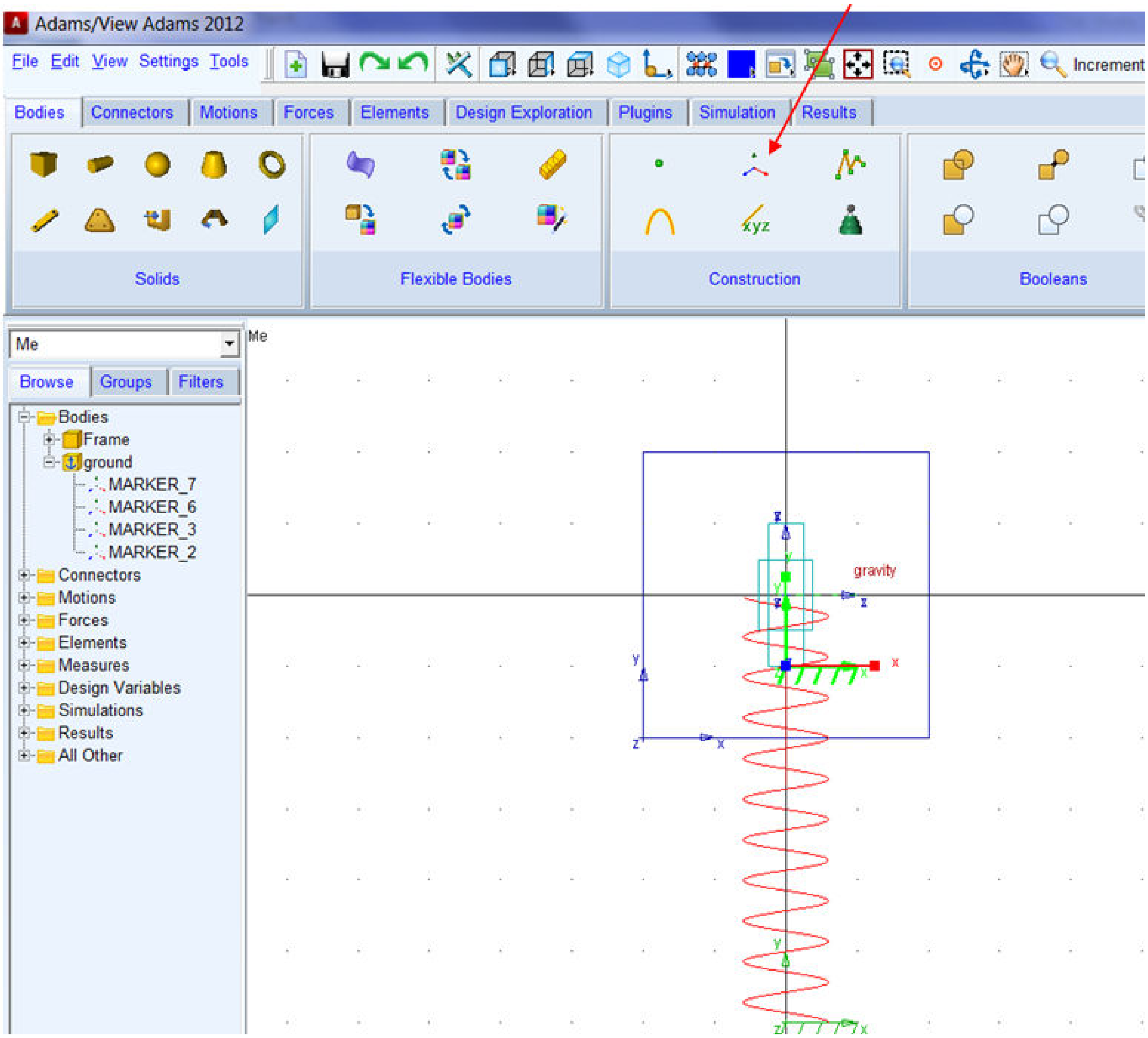
19- From Tab menu, select “Force” and then select “Spring”

20- Select the Frame.cm, then select the ground.marker (the one you just created in step 18)

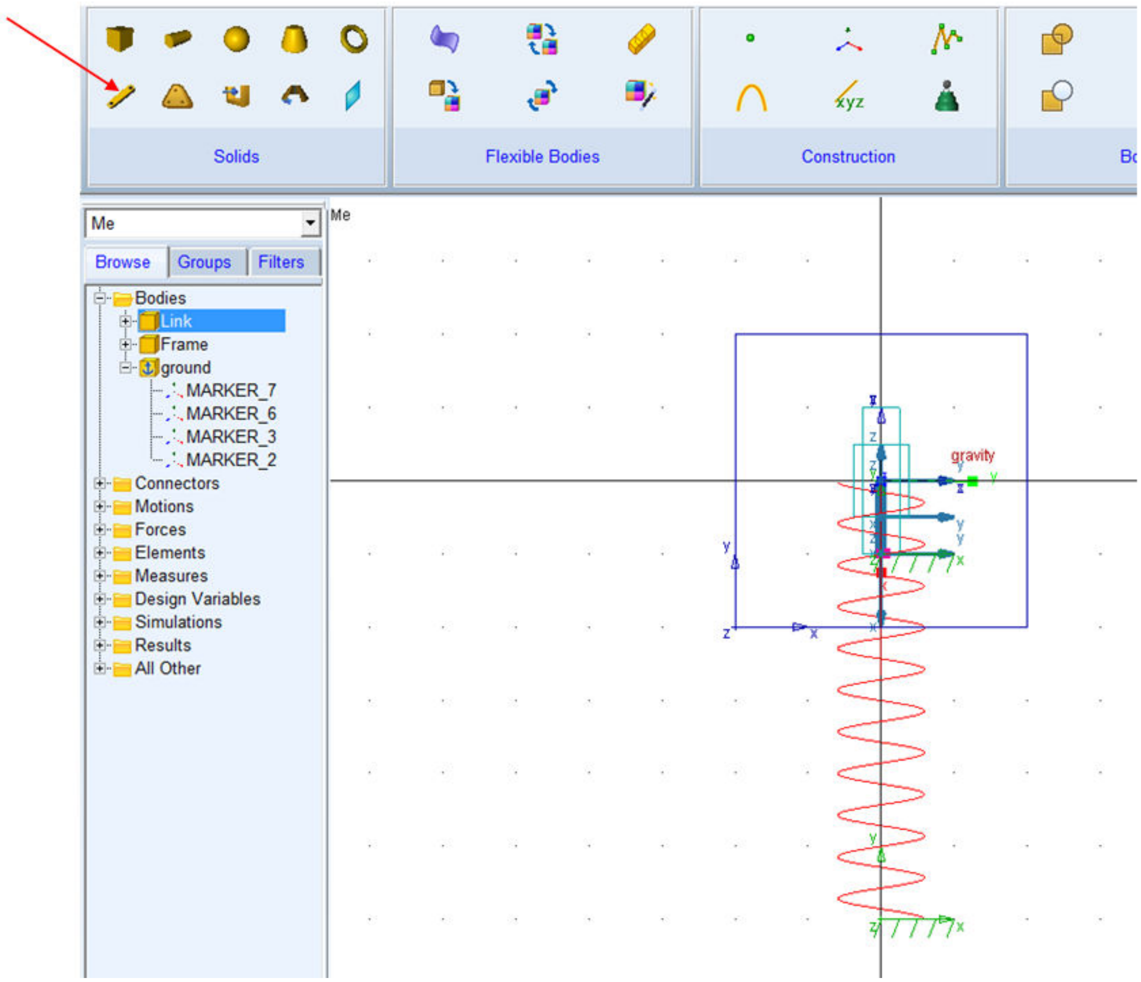
21- Right click on the spring, and choose “Modify” then let stiffness to be 600N/mm, Damping=0; Pre-load = 0 (You may want to turn off the damping graphics as well)



22- Create a Marker at (50,0,0) (exactly like step 17 and 18).



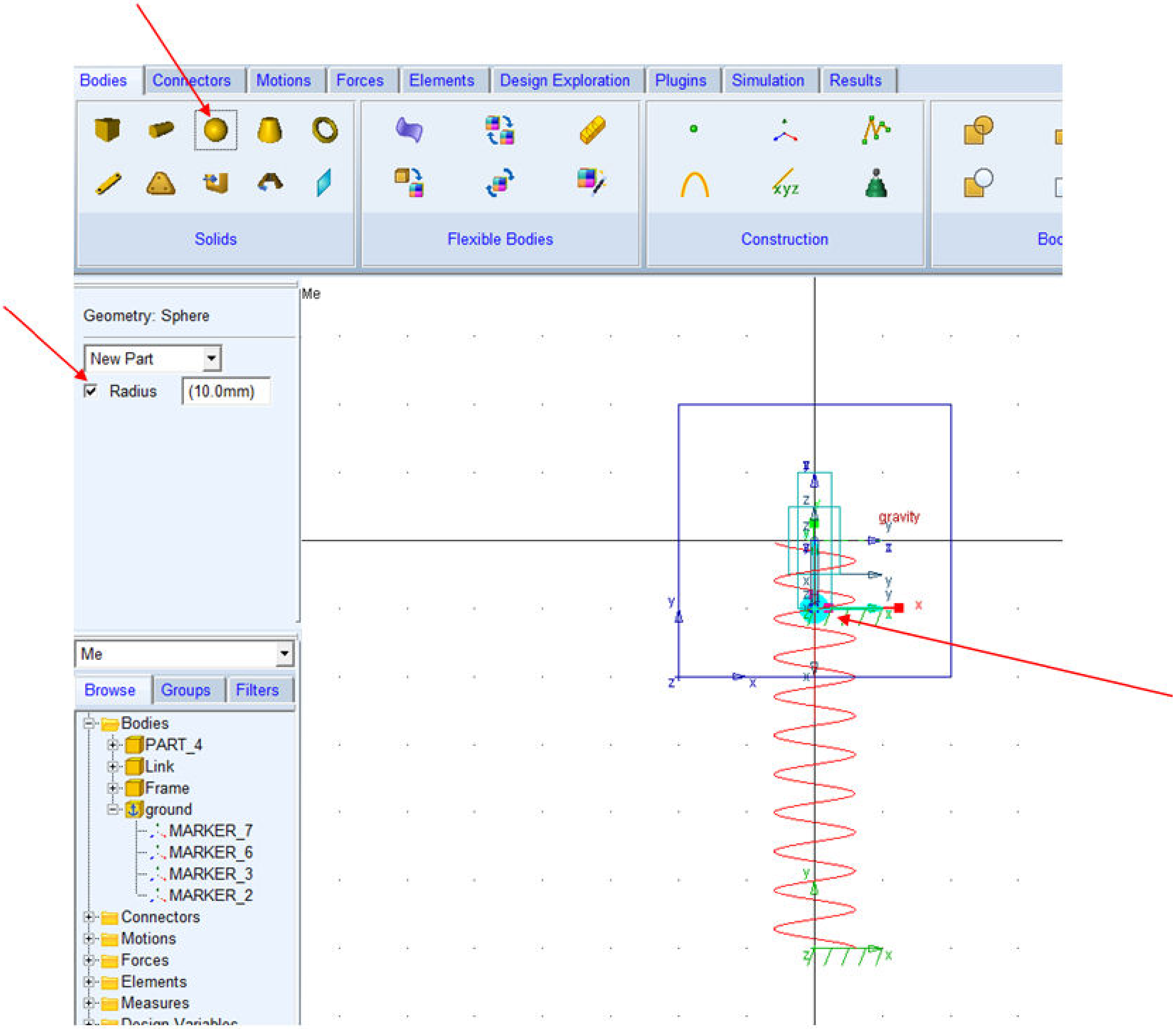
23- Create a "Link" between the Frame.cm and the Marker you just created in step 22.



24- Rename it to "Link"

25- Right Click on the link you just created and modify its width and depth to 1mm

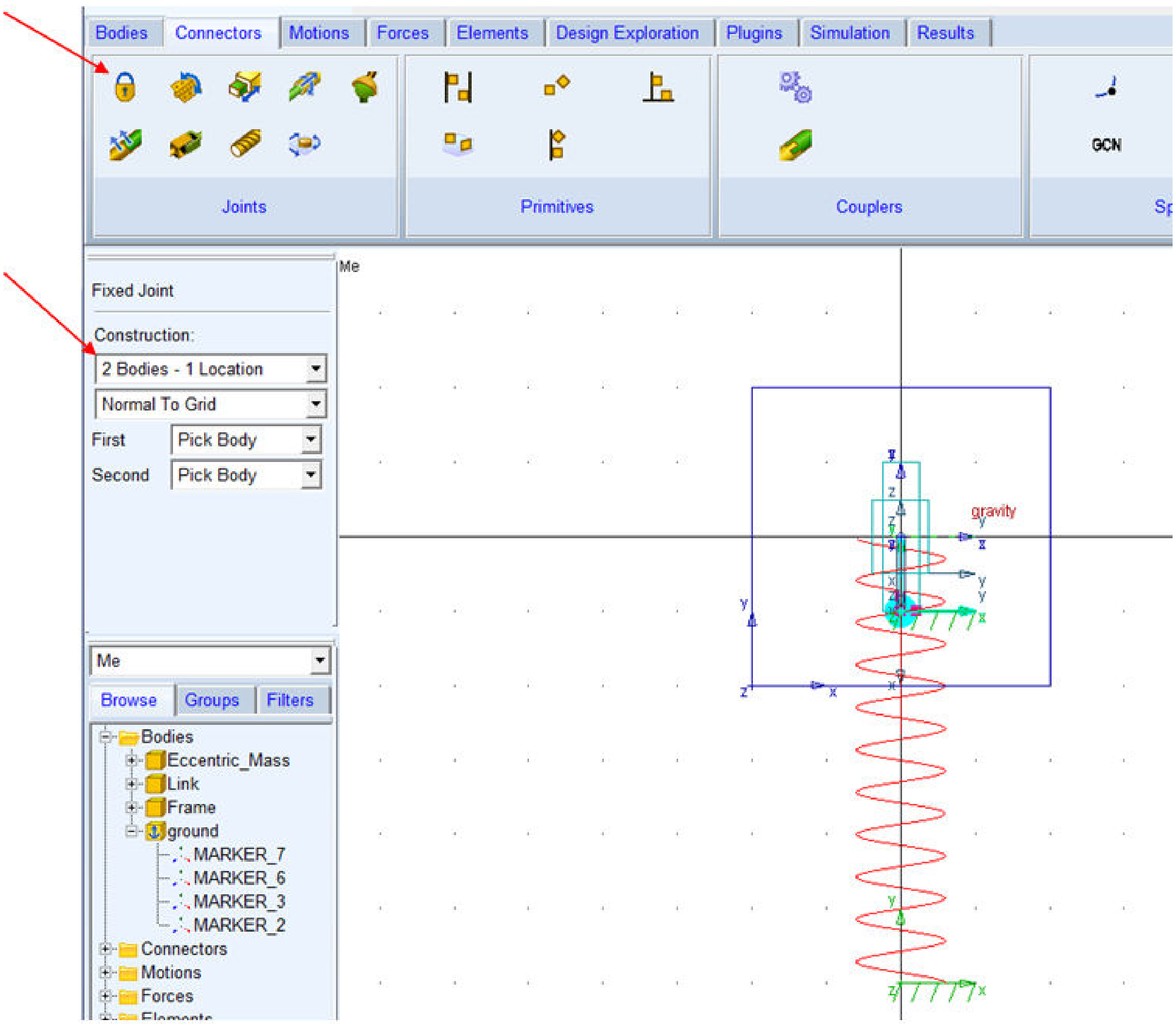
26- Create a "Sphere" with radius=10mm at the end of the "Link".



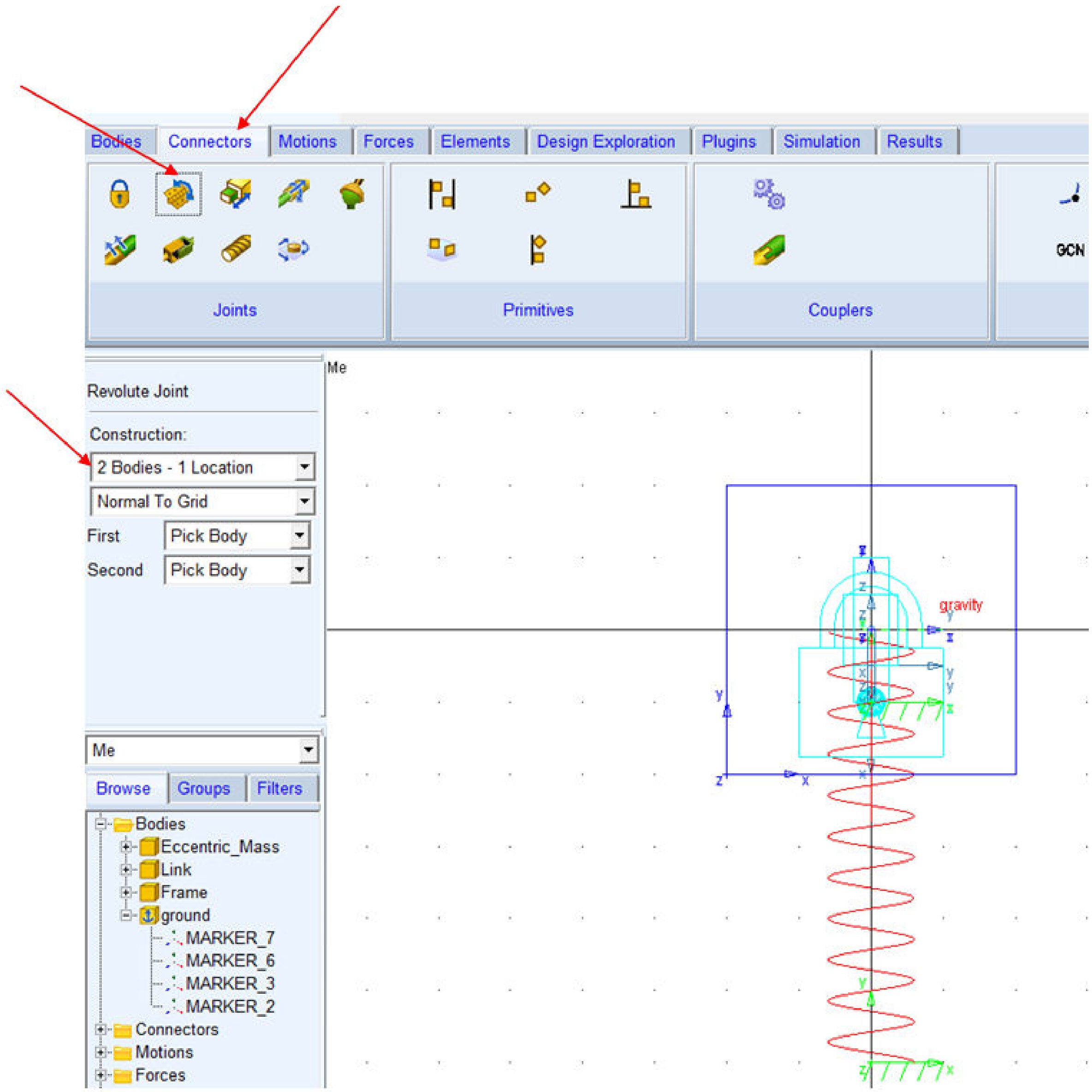
27- Rename it to "Eccentric_Mass".

28- Modify its mass to 0.3Kg.

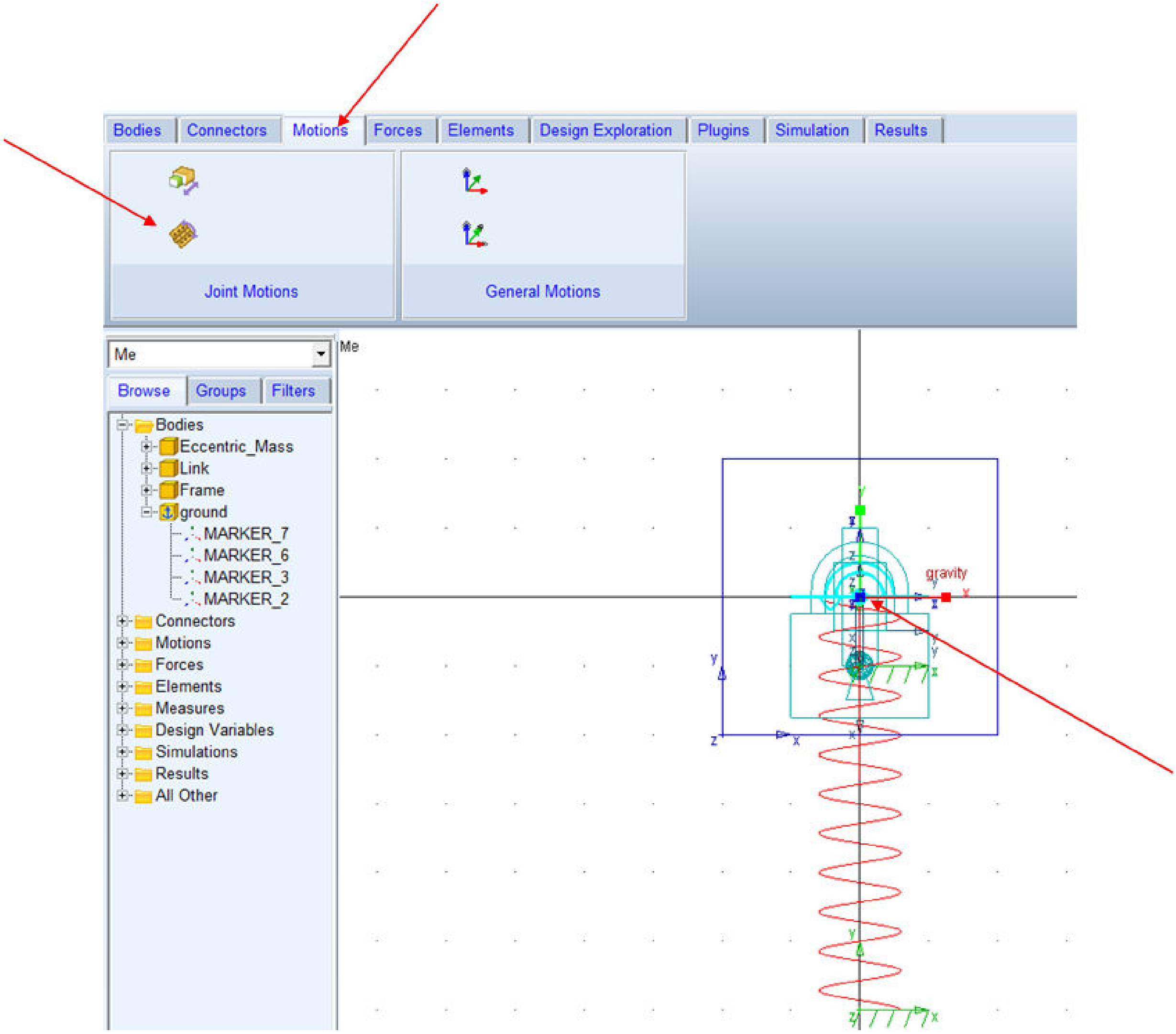
29- Connect the "Eccentric_Mass" and the "Link" together by: from "top menu" select "connectros" and then choose "Fixed Joint". (Joint them at the c.m. of " Eccentric_Mass".



30- By a "Revolute Joint" from the "Top menu" select "Connectors" and then select the "Revolute Joint" try to join the "Link" and the "Frame" at the Frame.cm

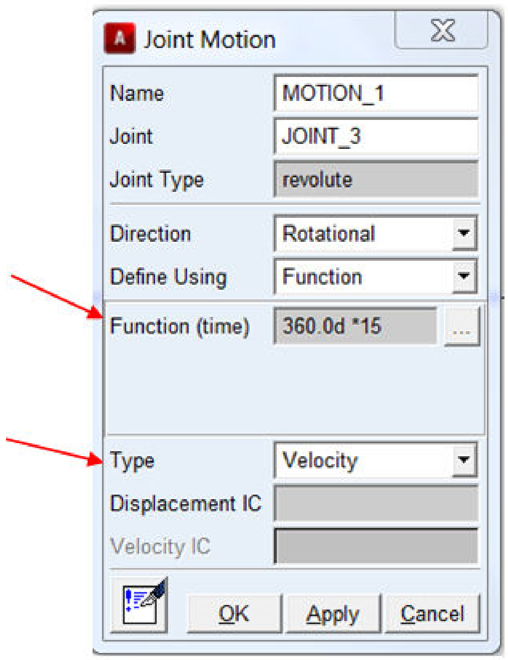


31- From "Top menu" choose "Motion", then select "Rotational Motion" and to apply this motion to the link; select the "Revolute joint" you just created in step 30.



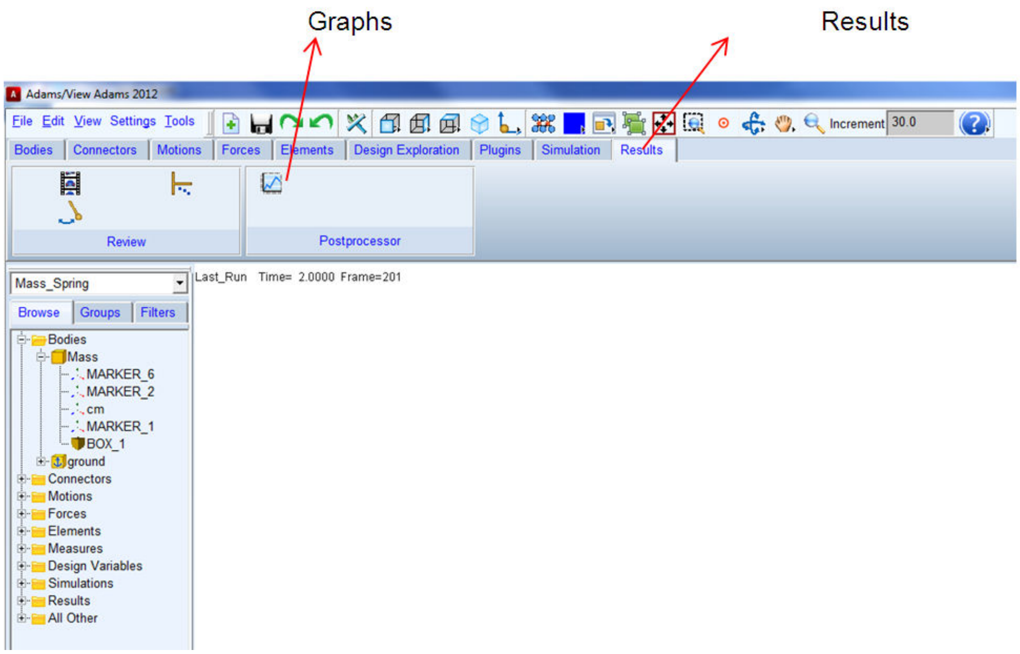
32- Right click on the "motion" you just created and modify it as the following window: (change the type to "Velocity" and the Function (time) to a constant speed of 360d*15) (note that since the unit we chose at the beginning was degree, the rotation speed is degree/second; so we have to add 360d. In other word, 360d*15 means the rotation speed is 15 revolutions per second)

Note: We are trying to choose a rotation speed for the system that is close to its natural frequency. What is the natural frequency? (Compute it with your hand calculation: $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$)

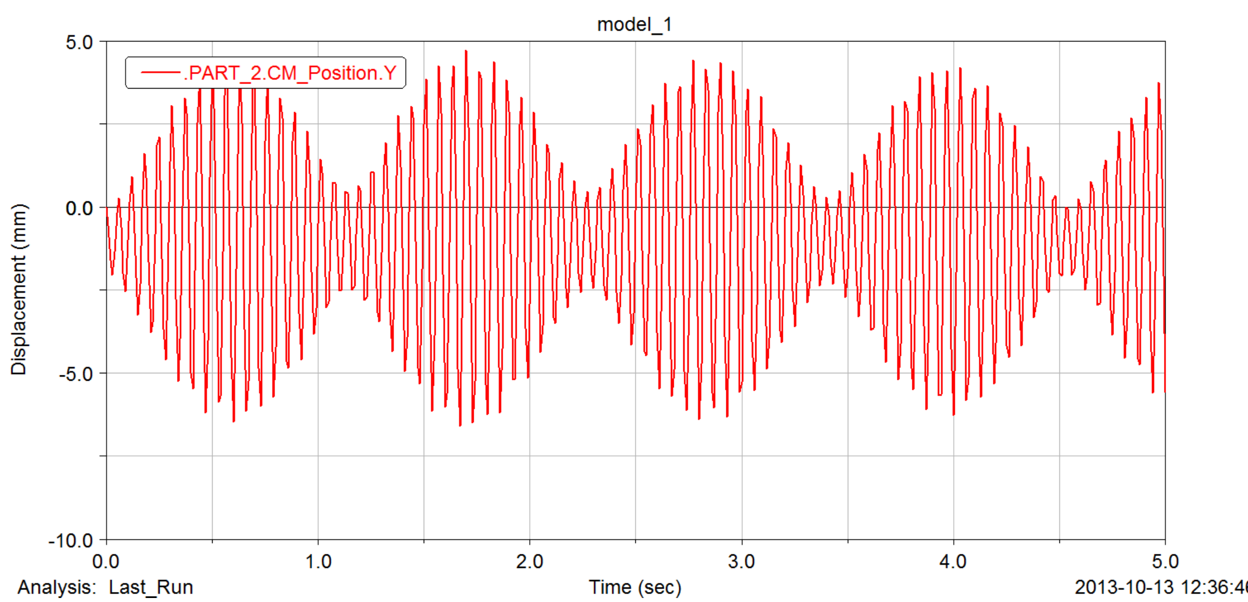


32- Run a simulation: 5Sec, with 5000 steps

33- From Tab menu select “Results”; then from main menu select “Postprocessor”



34- Produce the Mass.cm position graph in Y direction. (You can produce other graphs like, cm_velocity, Kinetic Energy, …)



35- Run a similar simulation when the rotation speed is exactly equal to the natural frequency of the system.

Assignment:

Design a Damper for the unbalance rotating system to minimize the vibration?

hint: try computing the damping for a resonance case (i.e. the system is rotating at the rotation speed about the natural frequency of the system) and the critical damping ratio of $\zeta = 1$.

Write a short repost including the damping computation for the system, and add the graph for the displacement of the main system in Y direction with and without damping at 3 different rotation speeds:

- Bellow the critical speed (resonance rotational speed)

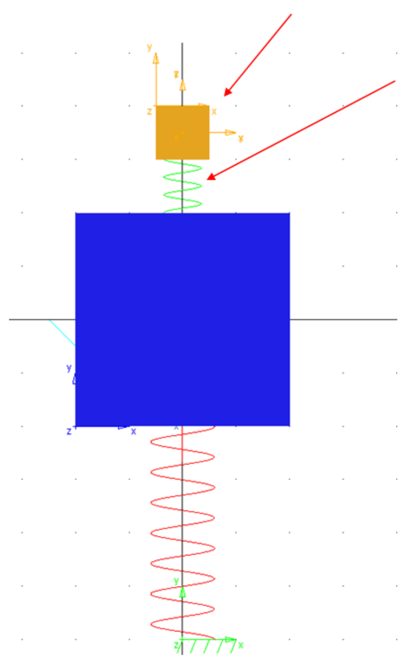
- At the critical speed (resonance rotational speed)

- Above the critical speed (resonance rotational speed)

Exercise (Optional): Design of Vibration Absorber for the eccentric mass system:

Compute the spring and mass for the vibrations absorber?

(**Hint:** choose a reasonable mass for example 1Kg; then try to compute the spring so that the frequency of the vibrations absorber be about the rotation of the unbalanced system)



Email a PDF file (1 page explanation + 3 Graphs) to ahmadpa20"gmail.com 10 days after your last (third) ADAMS class.