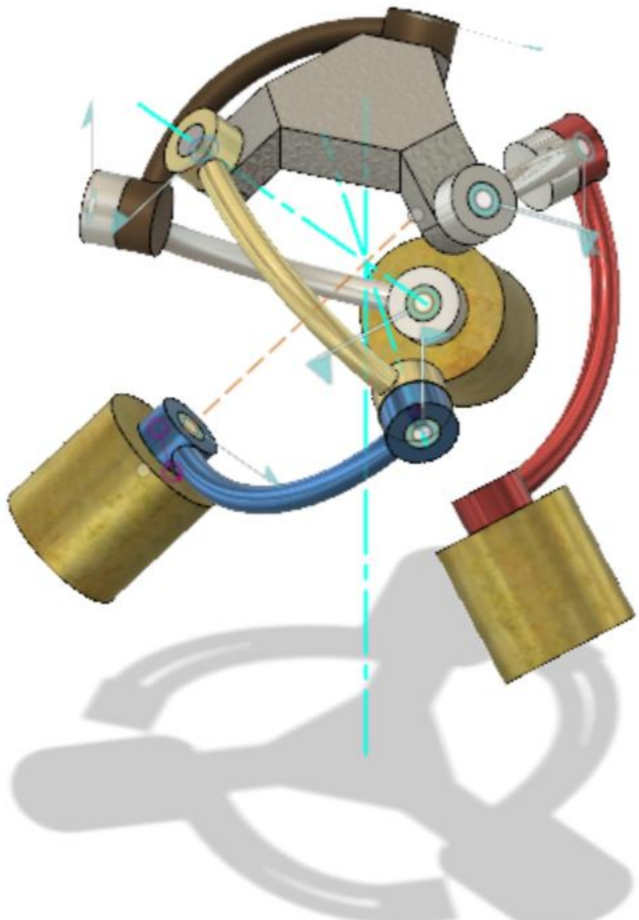
LEARNING DYNAMICS AND VIBRATIONS BY MSC ADAMS SOFTWARE



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. 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 is to review the fundamental of mechanical vibrations, and analytical dynamics by conducting some simple simulations of mass-spring-damping system, free and force vibrations, unbalance rotating systems; design of vibration absorber; modeling of constraints, contact modeling, impact modeling, multi body simulations, analyzing the complex , and non-linear motions.

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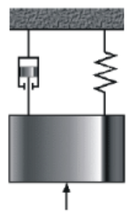
Chapter 1

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***.



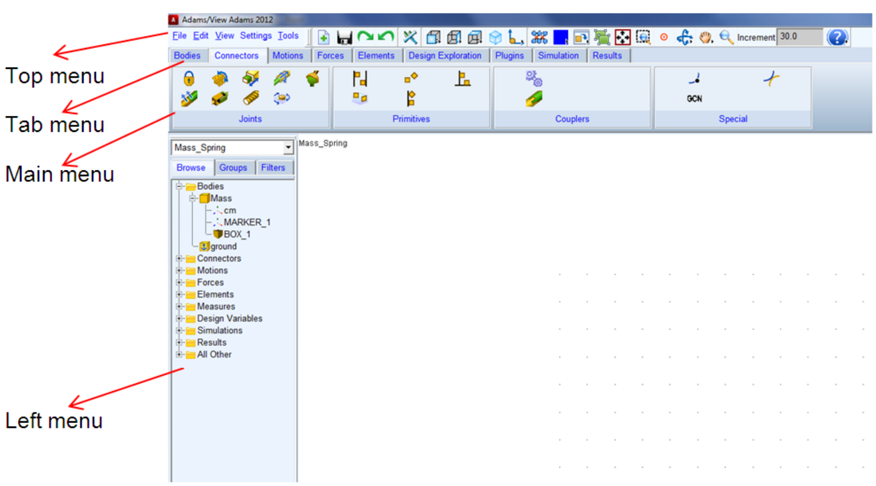
Starting ADAMS:

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.

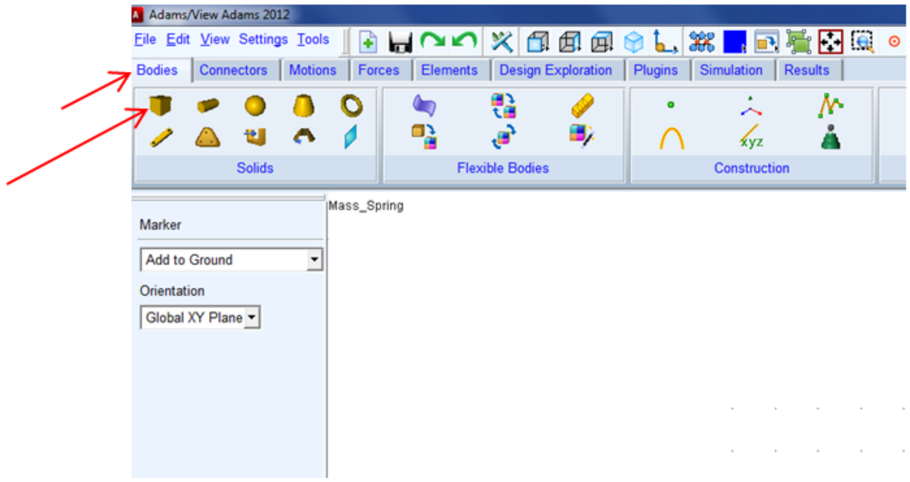
4- From top menu/settings/ coordinate, select your desire coordinate (default is Cartesian).



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".

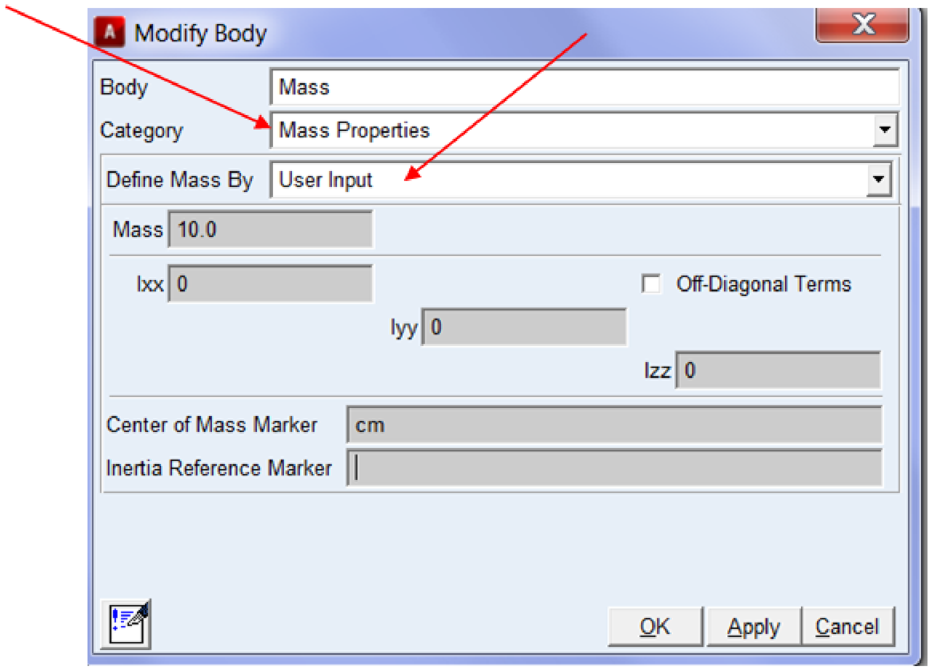
9- Right click on the block/Box, and modify its length, height, and width (200,100,100mm).

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?

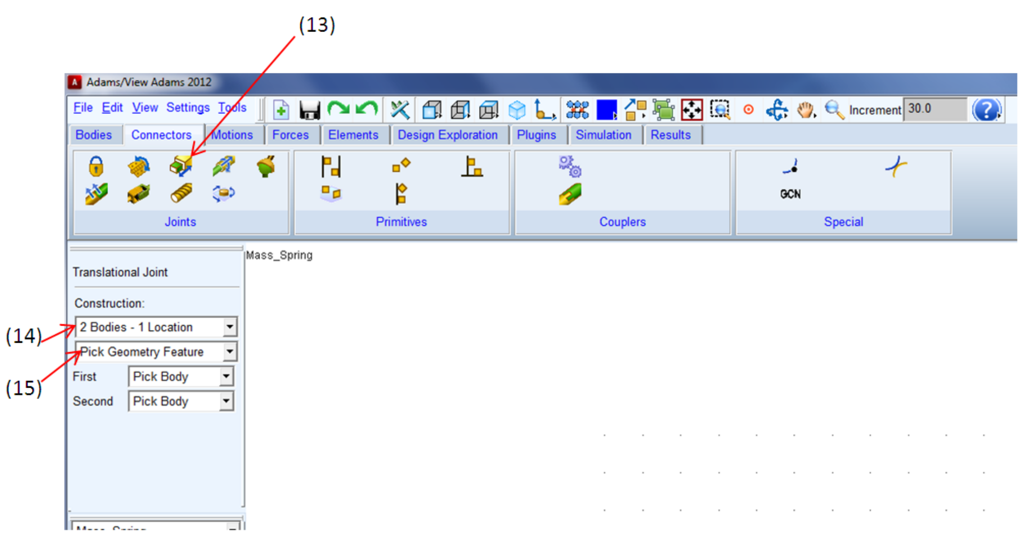
12- Right click on the created block, and choose Part: Mass/Modify ; then choose “Mass Properties”; and “User Input”. Let mass be 10 Kg and all moment of inertia 0 (why?).



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

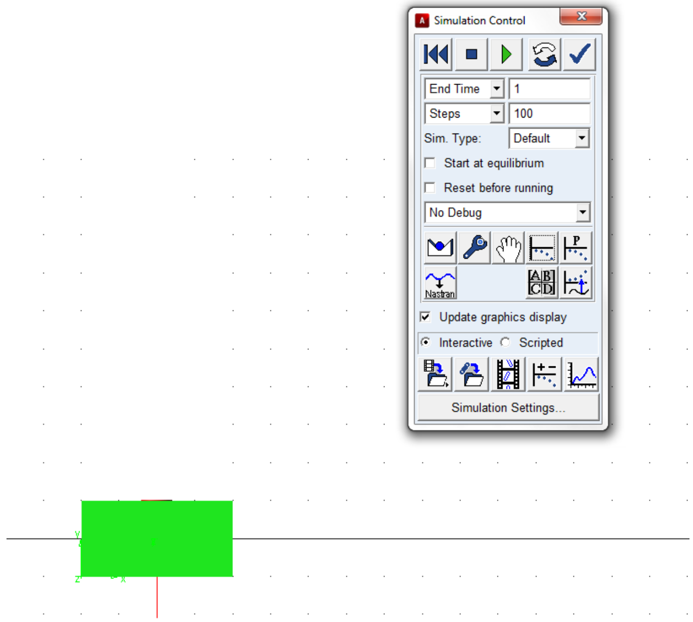
14- Select “2 Bodies-1 Location”.

15- Select “Pick Geometry Feature”.

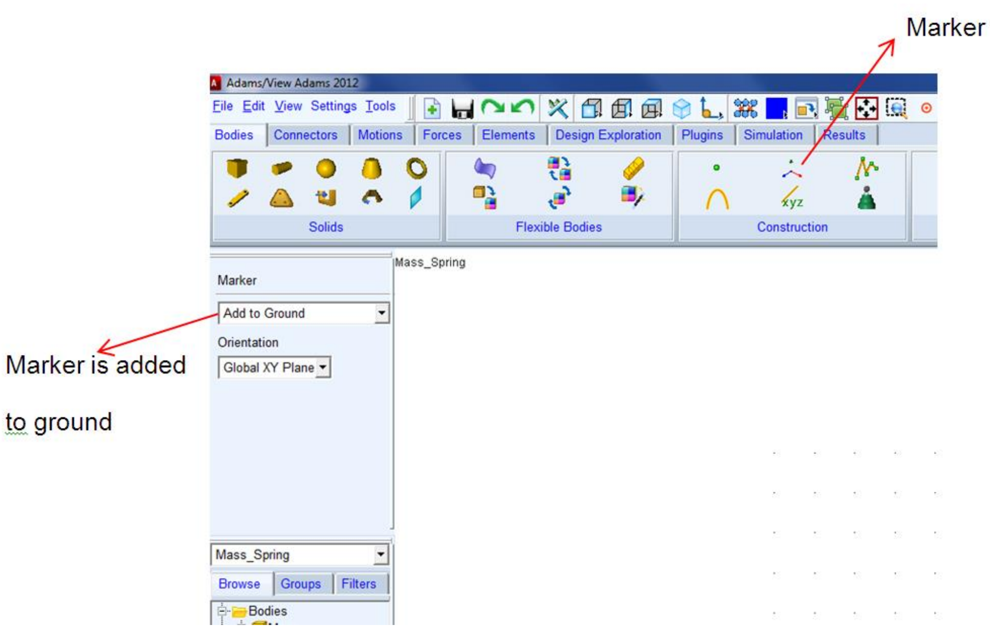


16- Select the Mass, then click on the ground, and then select the “Mass.cm”, and choose the direction vector.

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)



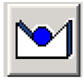
19- From Tab menu, select “Force” and then select “Spring”

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);

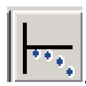
Damping=0; Pre-load = 0

22- Find Equilibrium Position

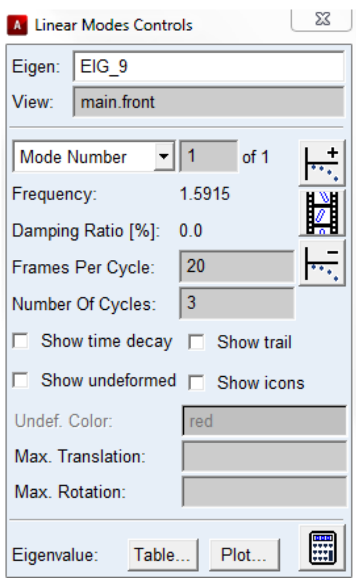
Click on the Find Static Equilibrium icon  in the Simulation Control Toolbox.

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, .

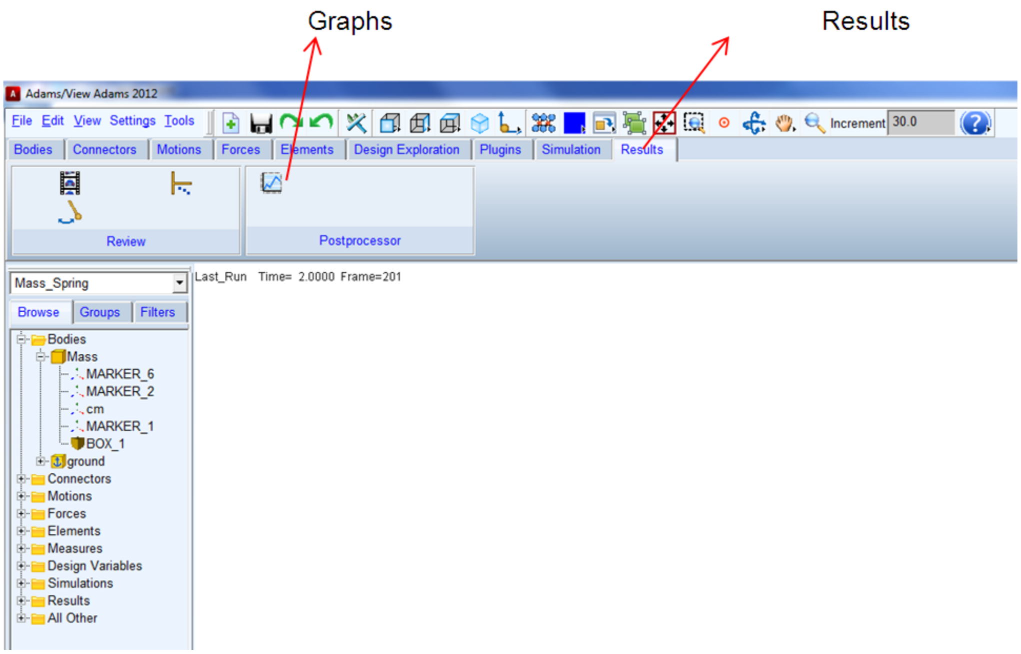
Second: Click '**Animate**' when ADAMS prompts you to view results of the Linear Mode analysis. The **Linear Modes Control Toolbox** Appears



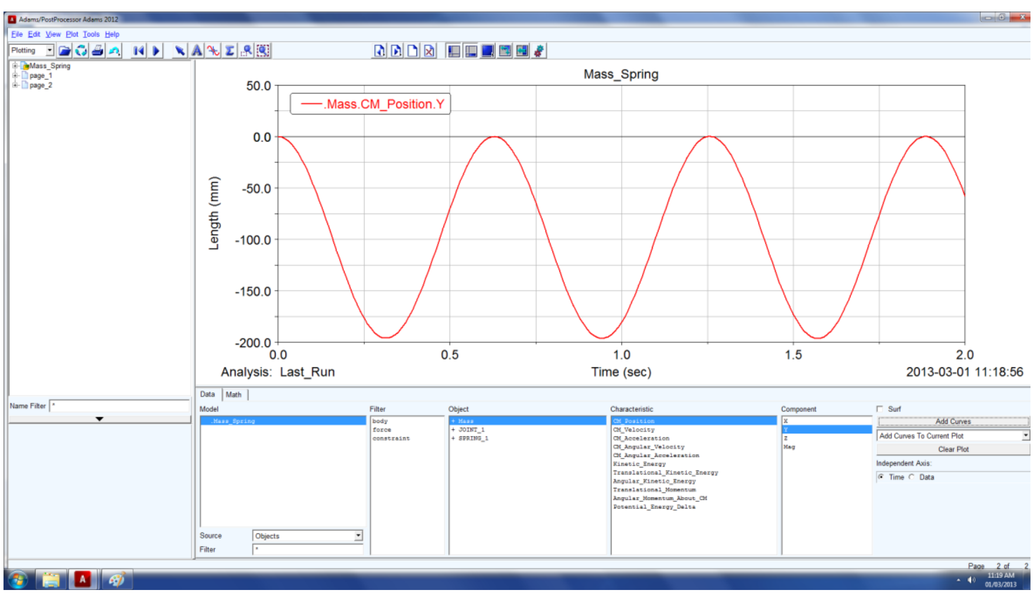
What is the natural frequency? (Compare it with your hand calculation: $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$)

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

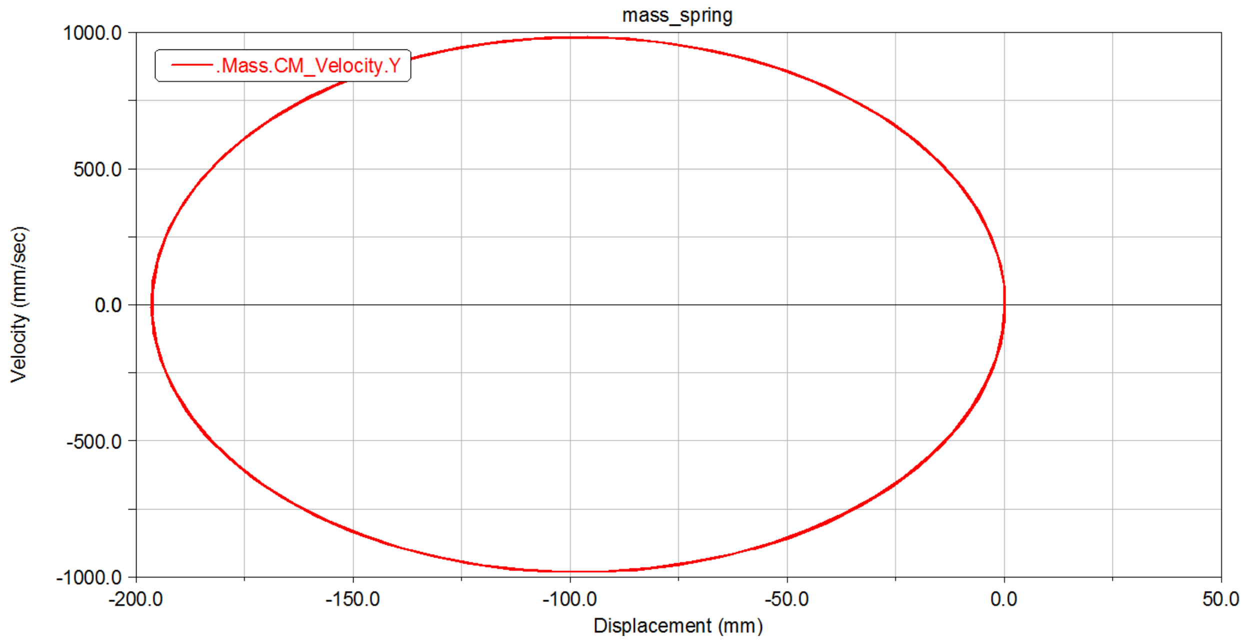
25- From Tab menu select “Results”; then from main menu select “Postprocessor”



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

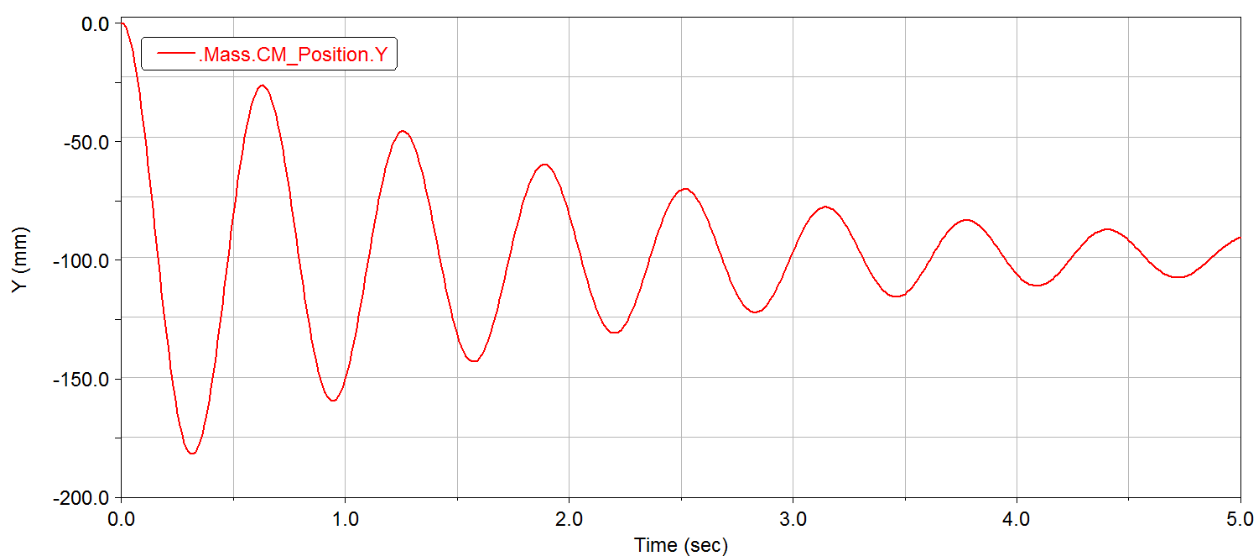


27- Produce a graph that shows variation of cm.velocity as function of cm.position (load animation and observe the behaviour)**(Phase Plane)**

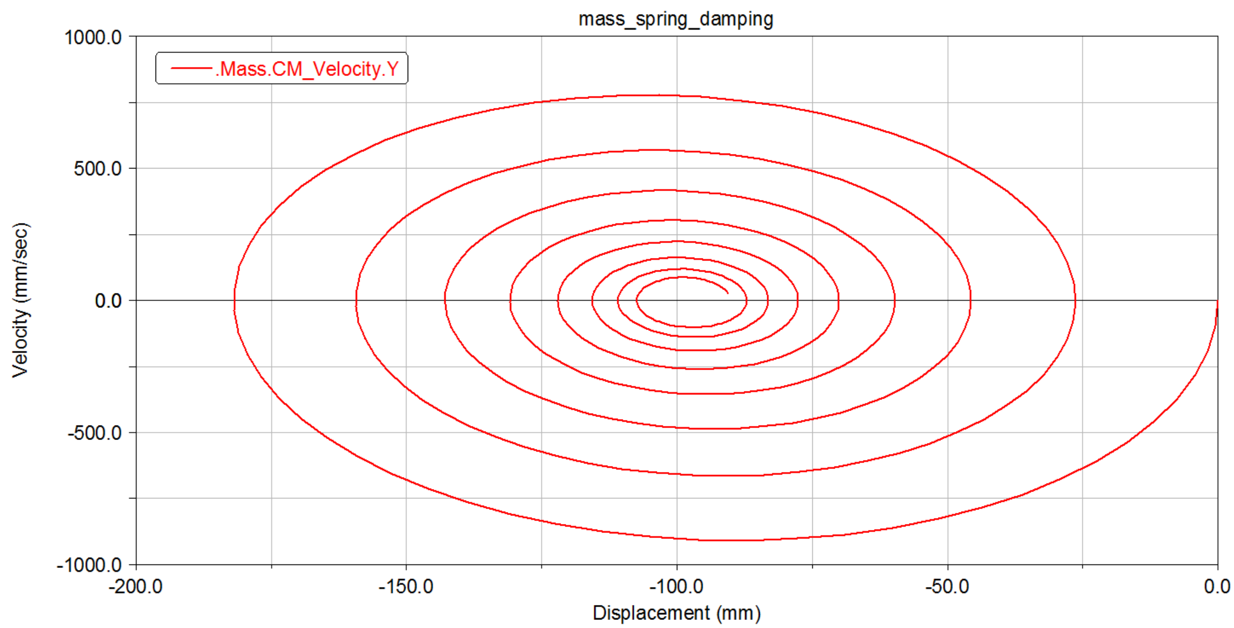


28- Choose damping =0.01 (N.sec/mm); and Run a simulation: 5Sec, with 500 steps

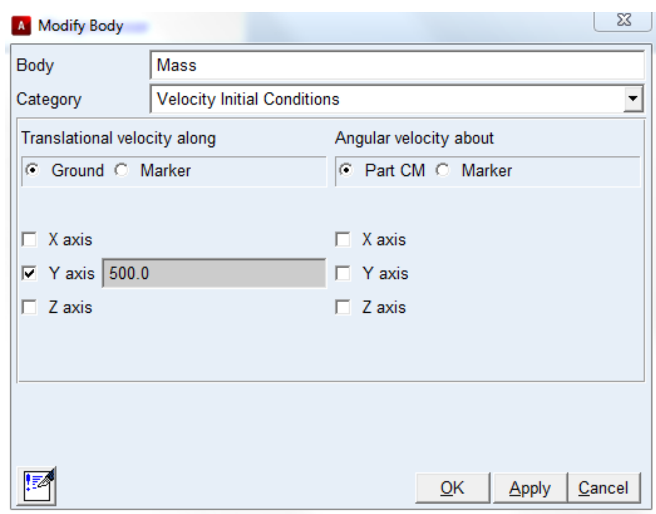
29- Produce the Mass.cm position graph in Y direction.



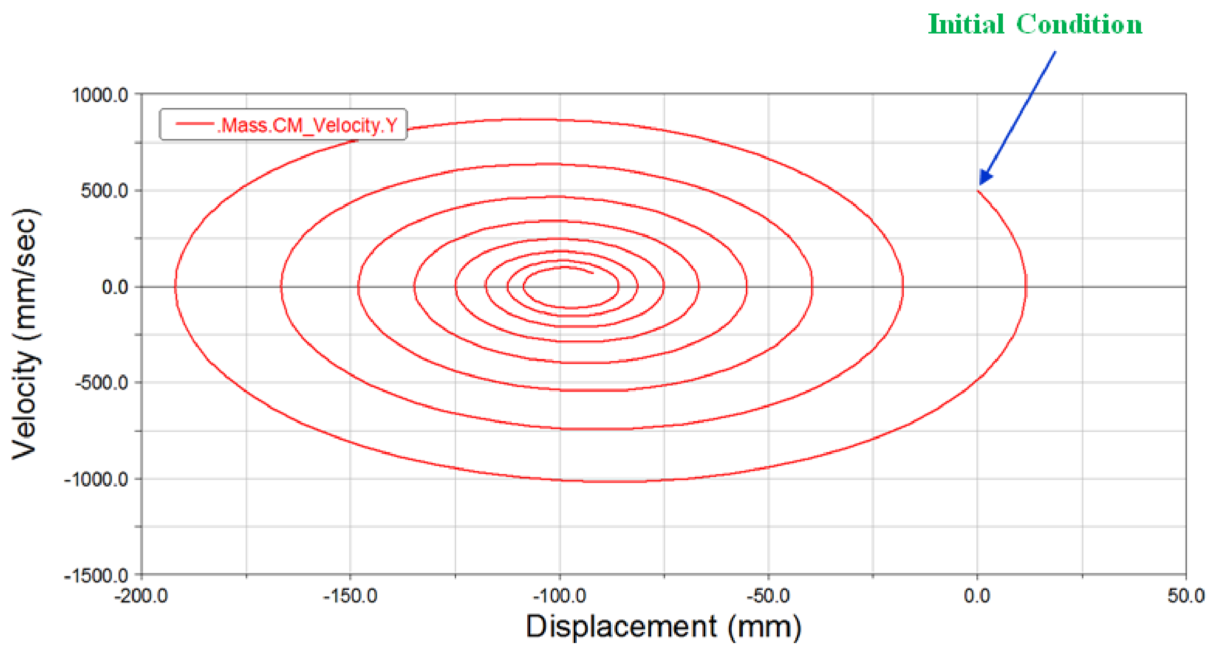
30- Produce a graph that shows variation of cm.velocity as function of cm.position (load animation and observe the behaviour)(Phase Plane)



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

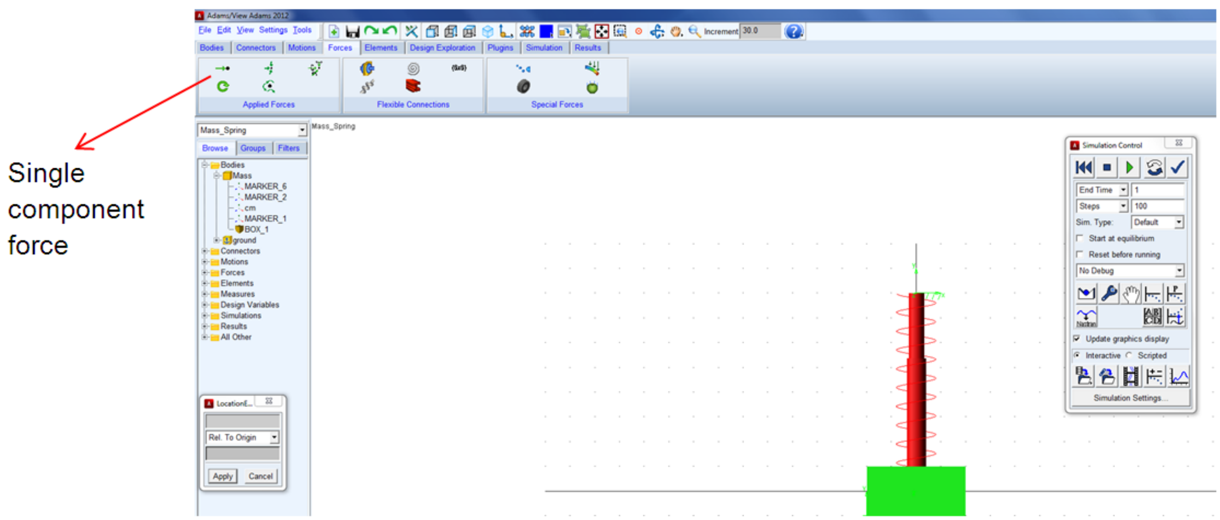


32- Run the simulation (5 sec, 500 steps) and produce the same graph like (procedure 30); investigate the dynamic behaviour.



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

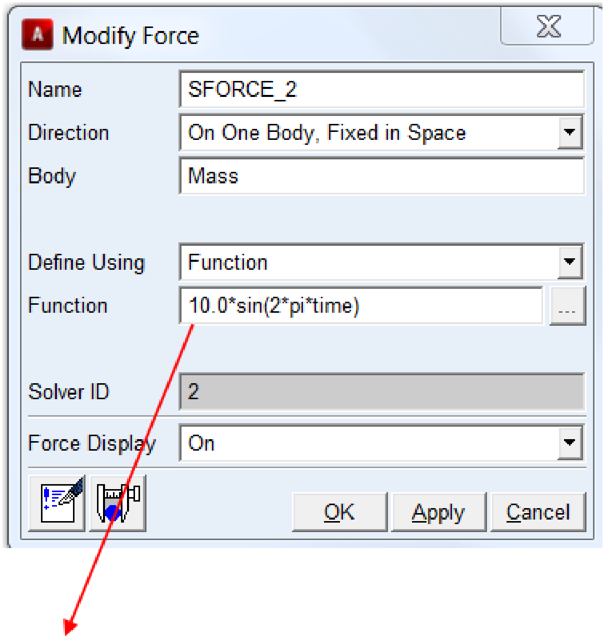
33- From Tab menu/Forces, select “single component force” and then select mass, then select Mass.cm, and direction of force (in –Y direction)



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)

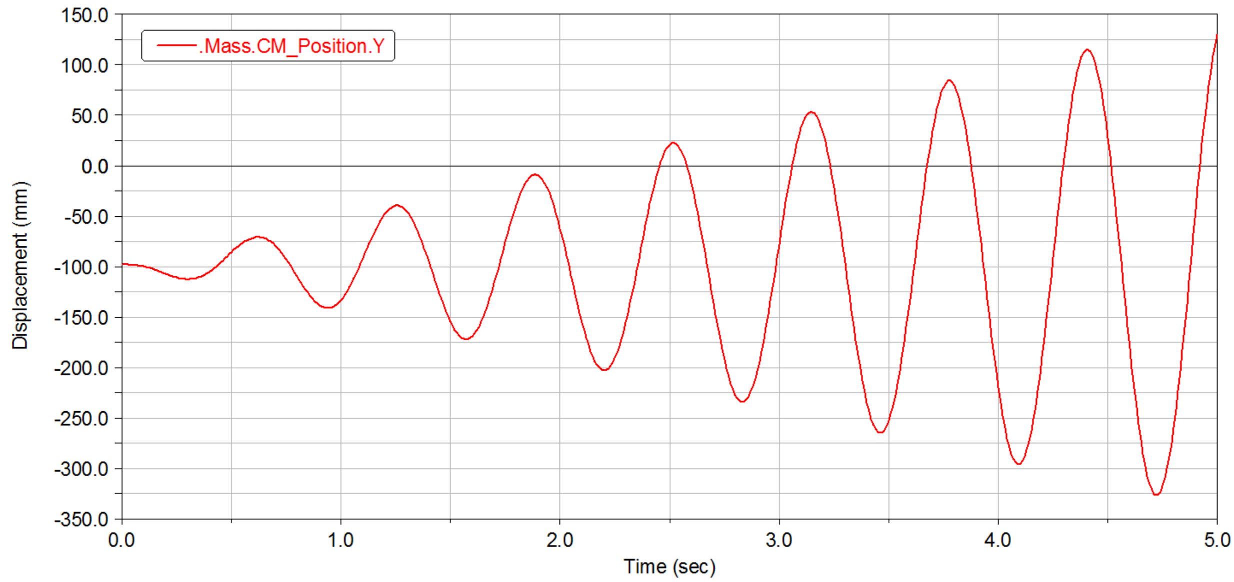
36- Modify the force to $F_0 \sin(2\pi f t)$ (for example: choose $F_0 = 10N$and $= 1\ Hz$) observe the transient and steady-state response. (Don't forget to tick "Start from equilibrium" in simulation toolbox)



$10\ sin(2\pi t)$

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

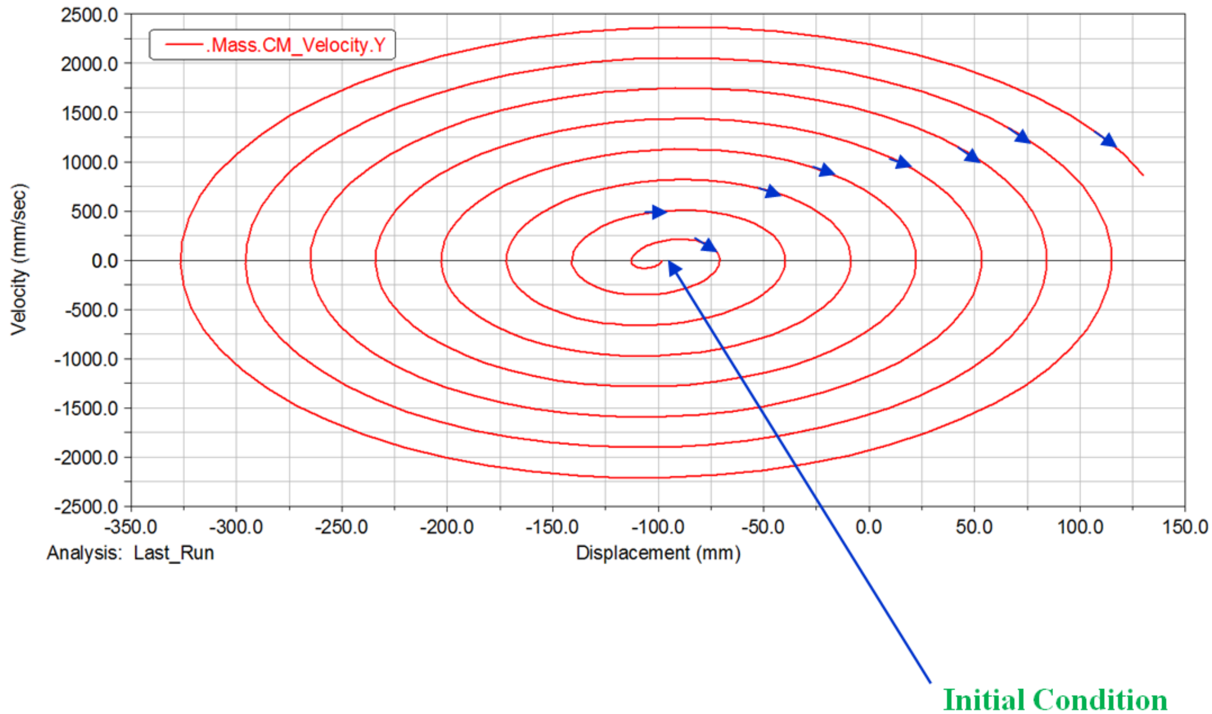
$$(m\ddot{x}(t) + kx(t) = F_0 \sin(\omega_n t))$$

has the form

$$x(t) = A\omega_n t \cos(\omega_n t)$$

(Investigate this for yourself later))

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

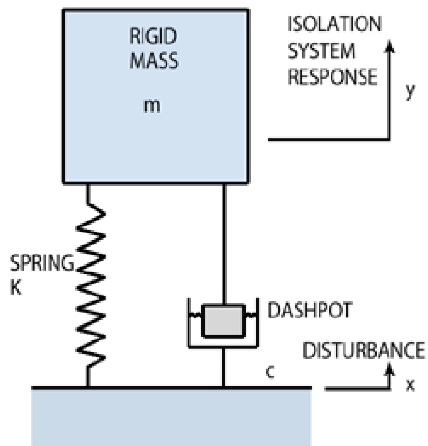


39- Set the damping to be again 0.01

40- Repeat 37 and investigate the results.

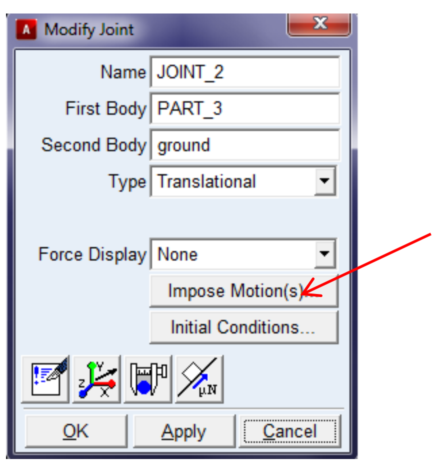
Assignment:

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**.**



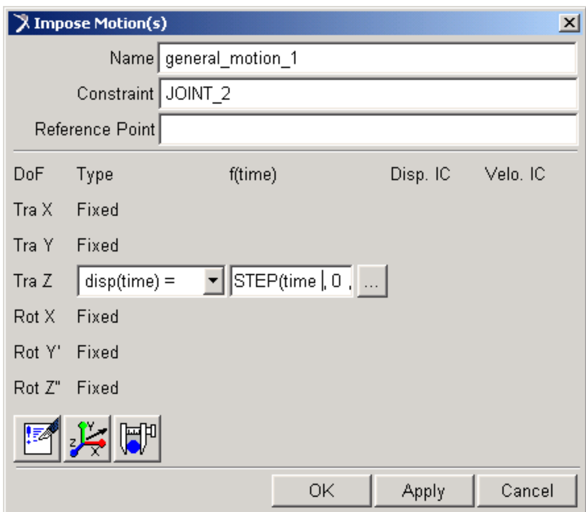
The only direction in which motion can be imposes is Tra Z. Change the motion from free to disp(time) = from the pull-down menu and type the following expression in the window to the right of 'disp(time)=':

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.

Chapter 2

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* $\boldsymbol{m.e. = 0.03 \times 50\ Kg.mm}$

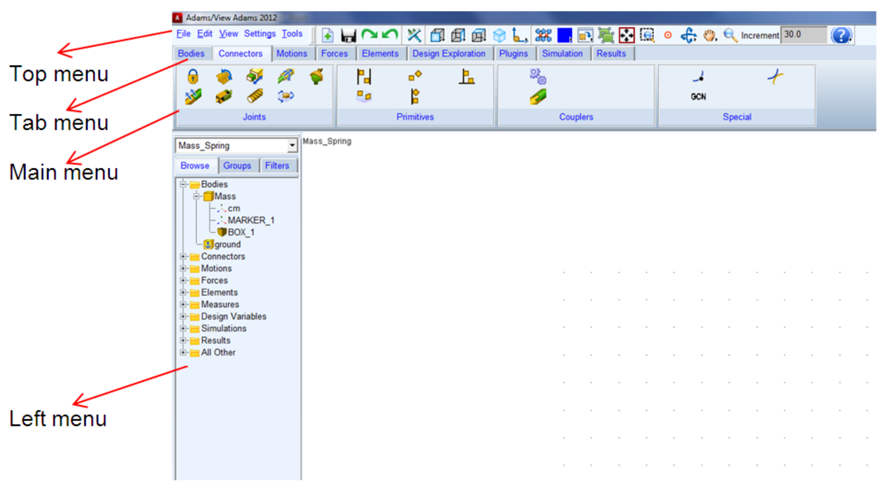
Starting ADAMS:

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.

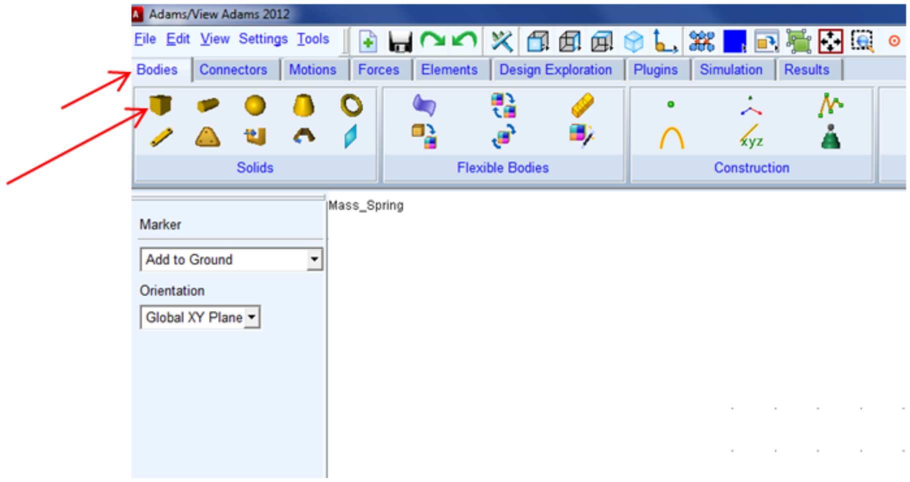
4- From top menu/settings/ coordinate, select your desire coordinate (default is Cartesian).



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”

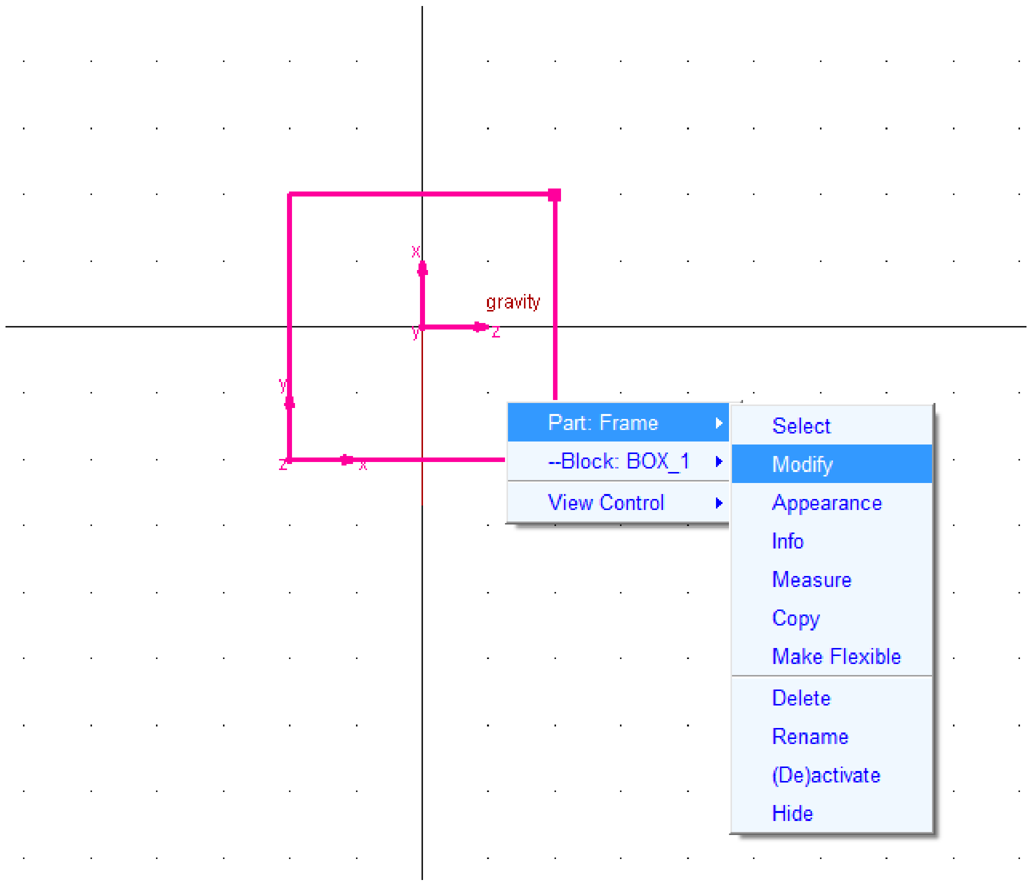
9- Right click on the block/Box, and modify its length, height, and width (200,200,200mm)

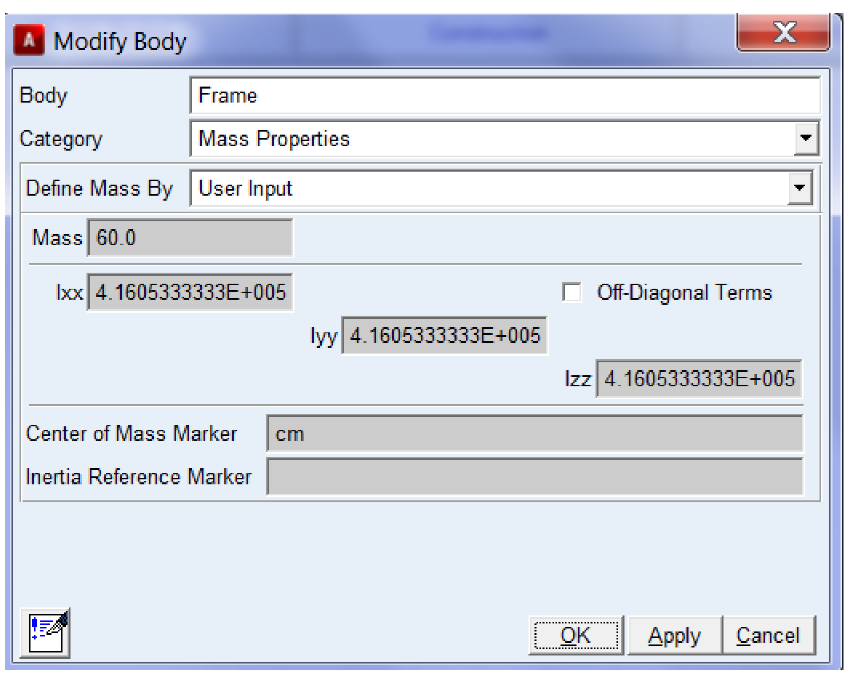
10- From left menu/Bodies/Frame, right click on Marker_1 and modify it to (-100,-100,-100) (if your chosen units is mm)

(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.

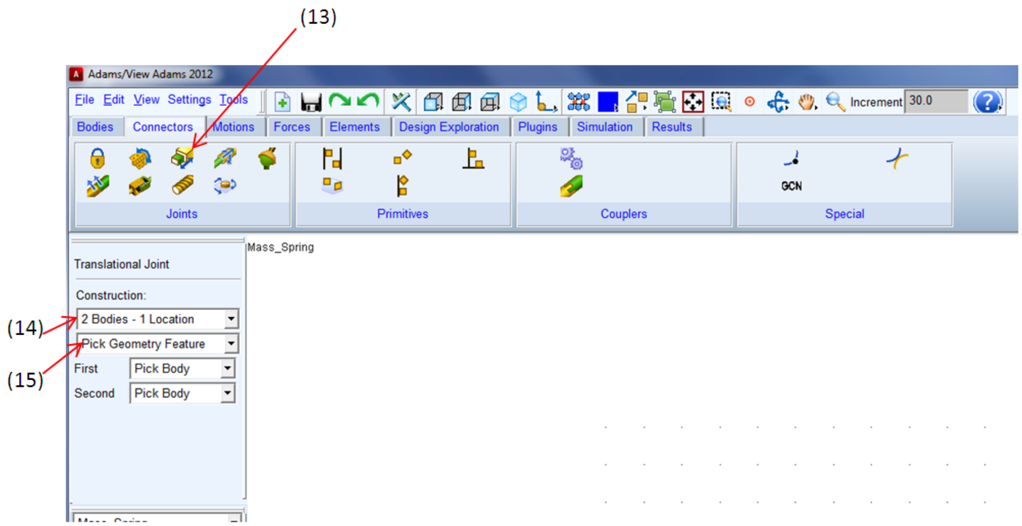




13- From Tab menu select: “Connectors” then select “Translational Joint”

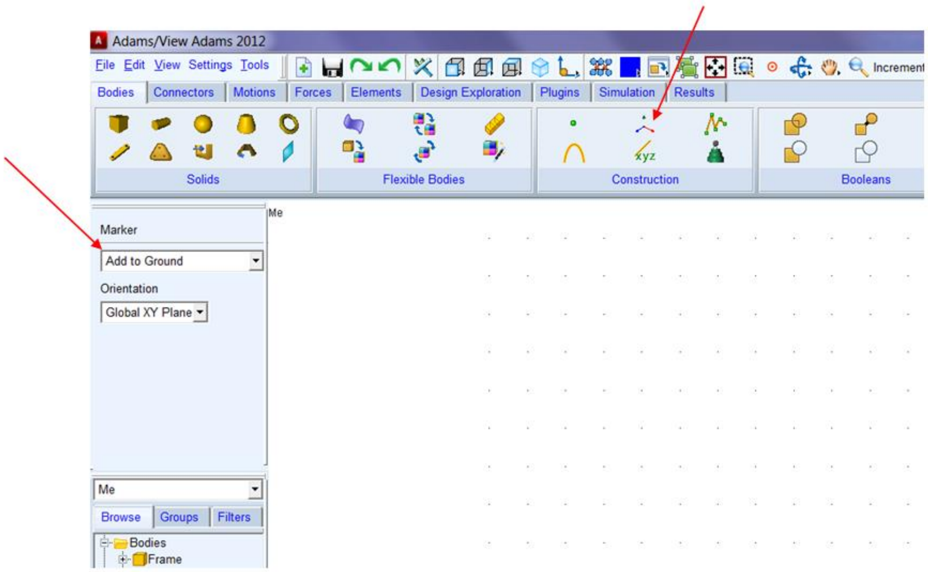
14- Select “2 Bodies-1 Location”

15- Select “Pick Geometry Feature”

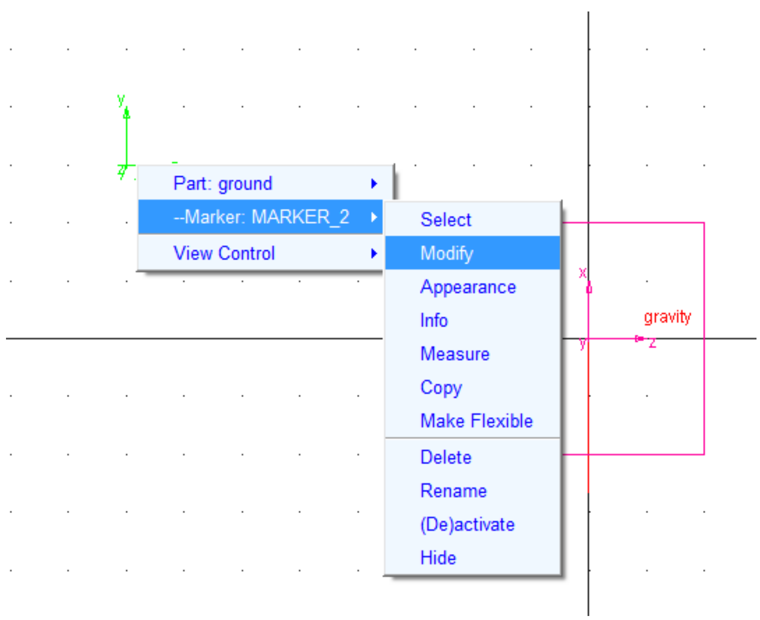


16- Select the Mass, then click on the ground, and then select the “Frame.cm”, and choose the direction vector.

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).



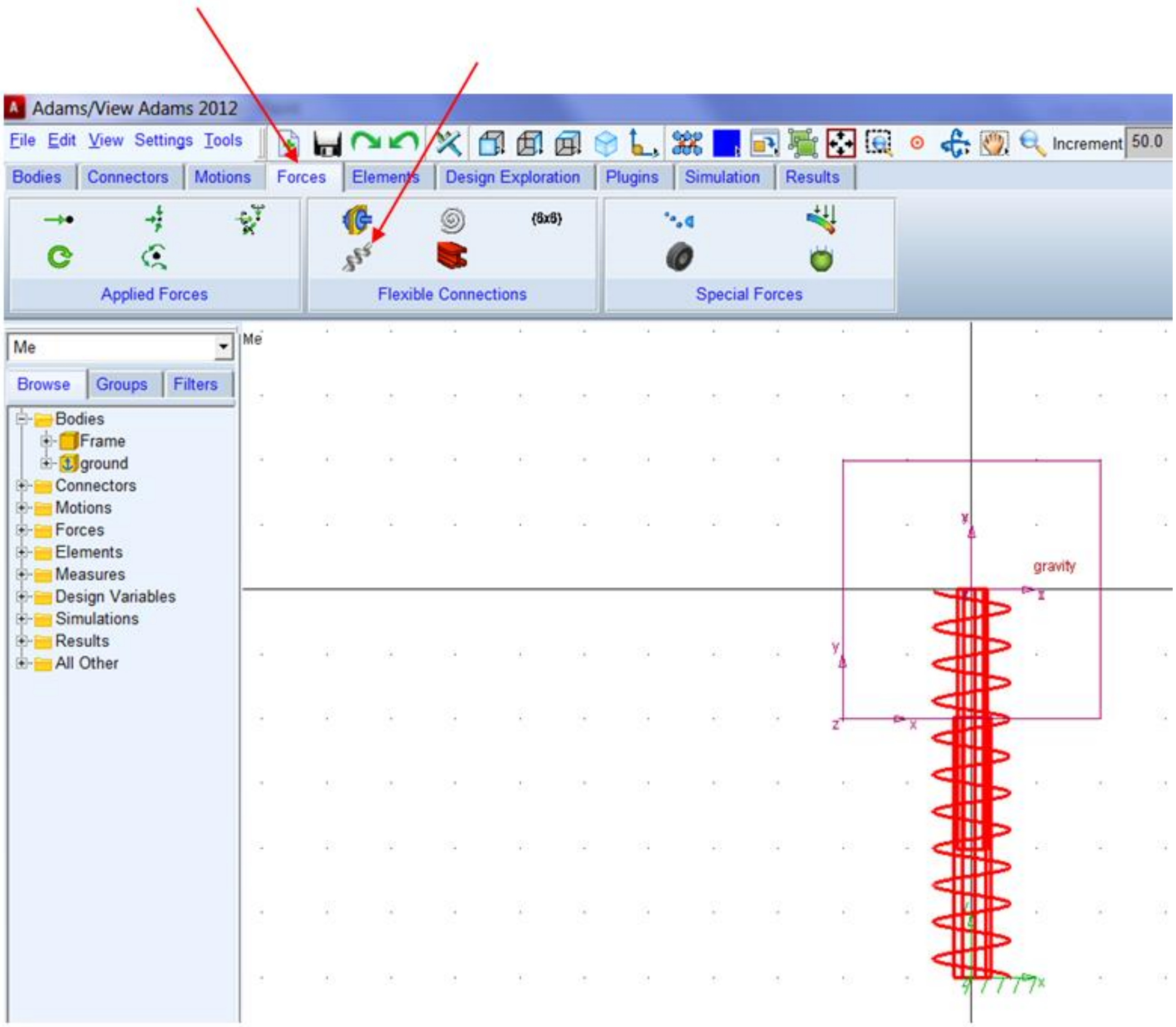
18- Right Click on the Marker you just created; and modify it to (0,-300,0)



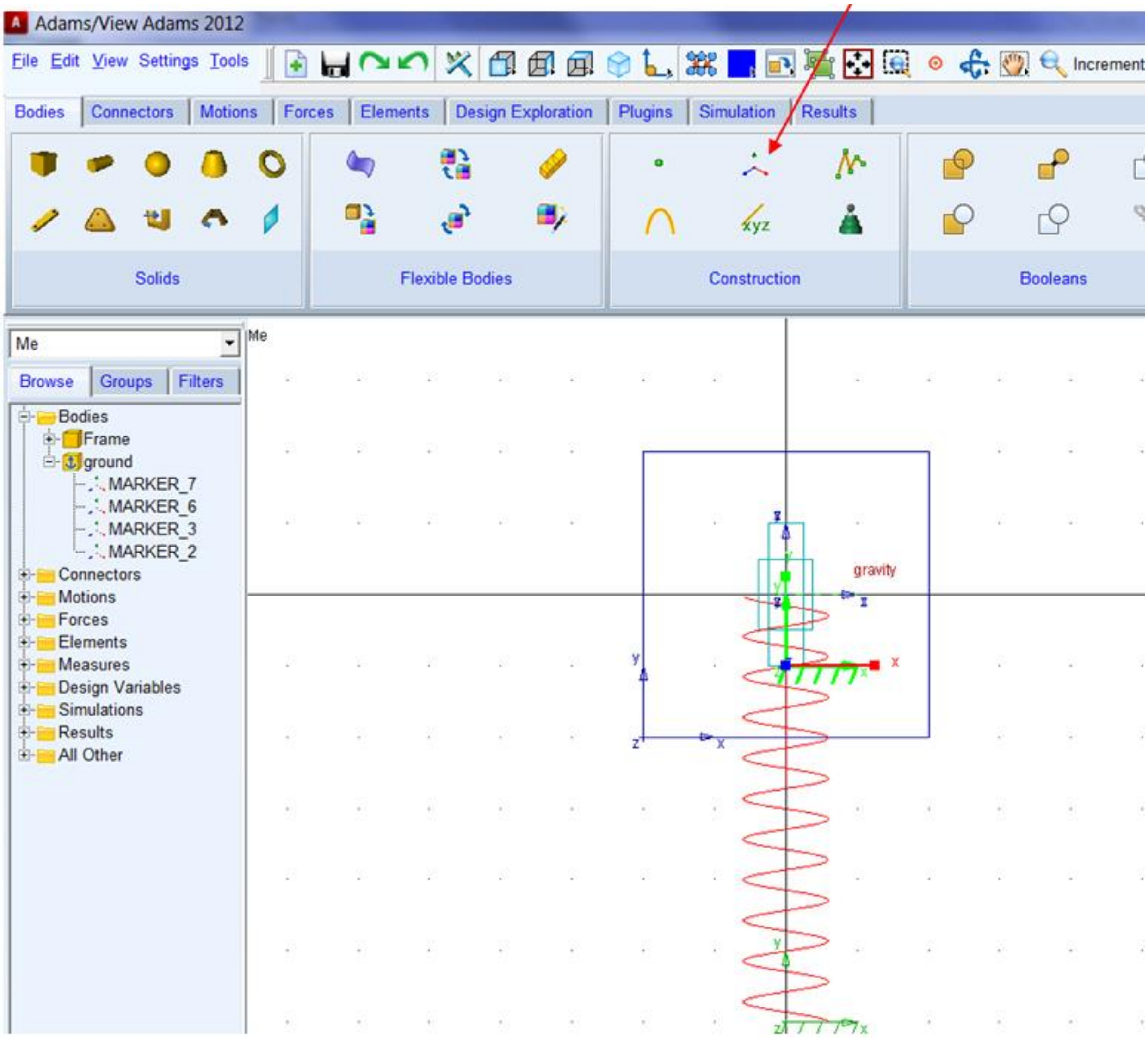
19- From Tab menu, select "Force" and then select "Spring"

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

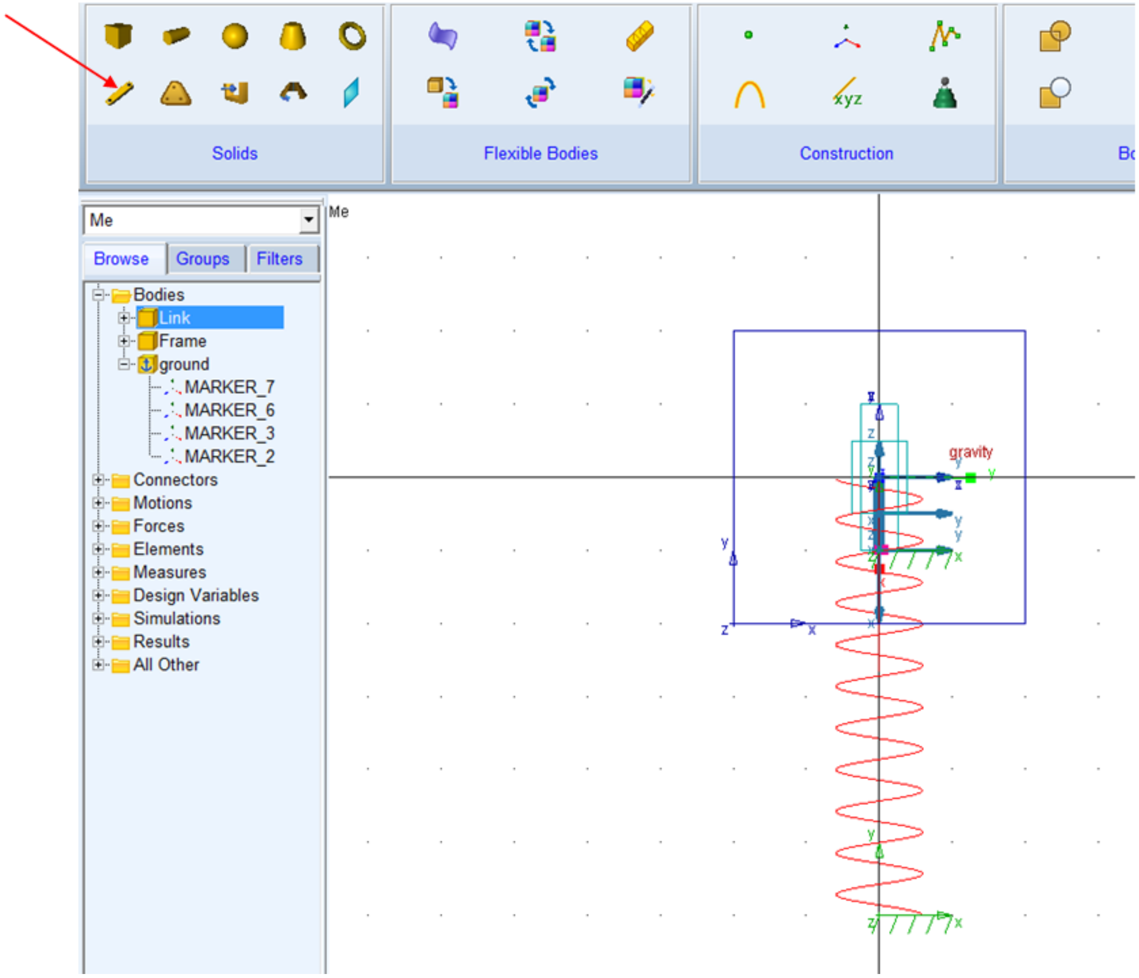
21- Right click on the spring, and choose "Modify" then let stiffness to be 600N/mm, Damping=0; Pre-load = 0 (You may want to turn off the damping graphics as well)



22- Create a Marker at (0-5,0,0) (exactly like step 17 and 18).



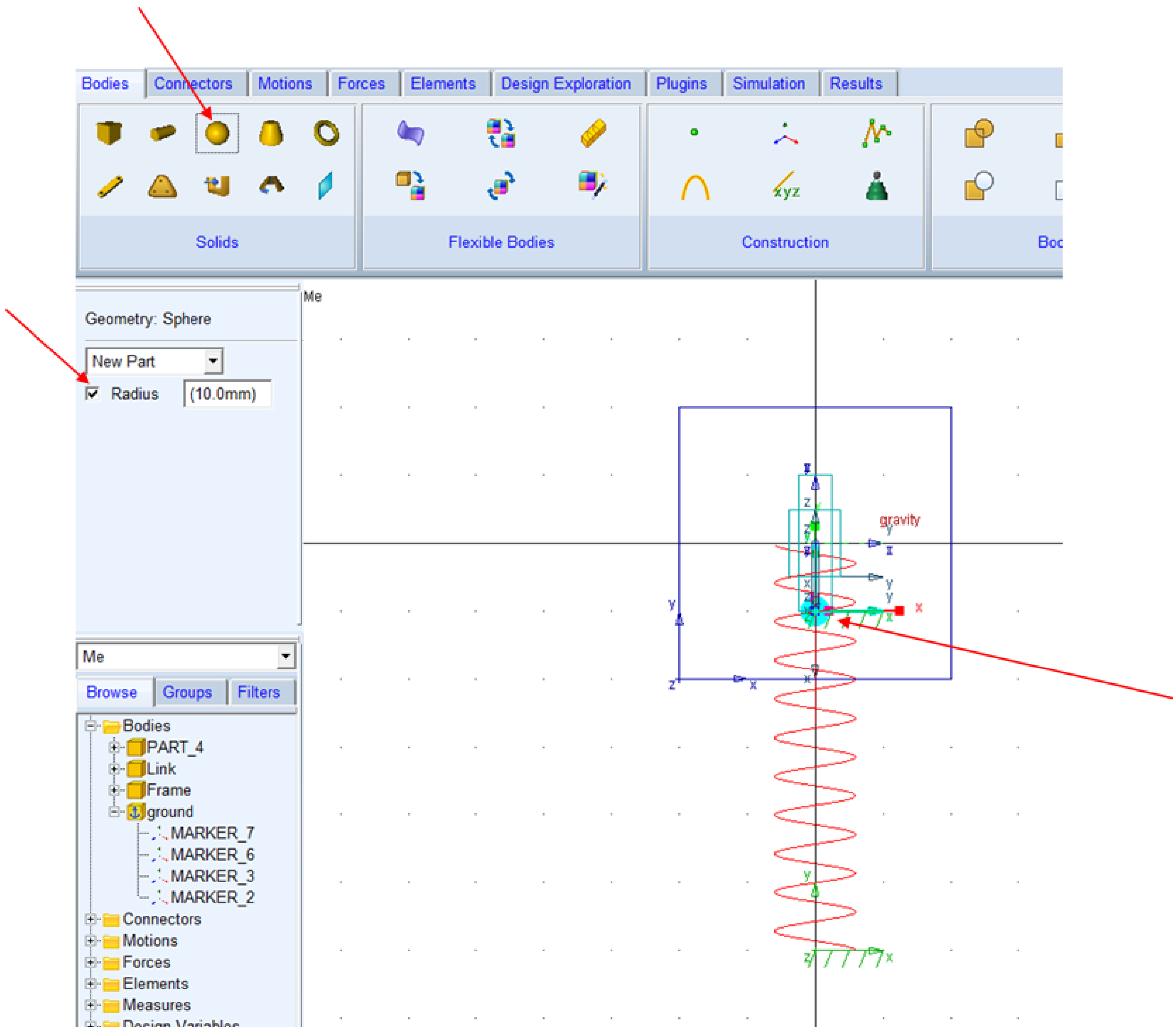
23- Create a "Link" between the Frame.cm and the Marker you just created in step 22.



24- Rename it to "Link"

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

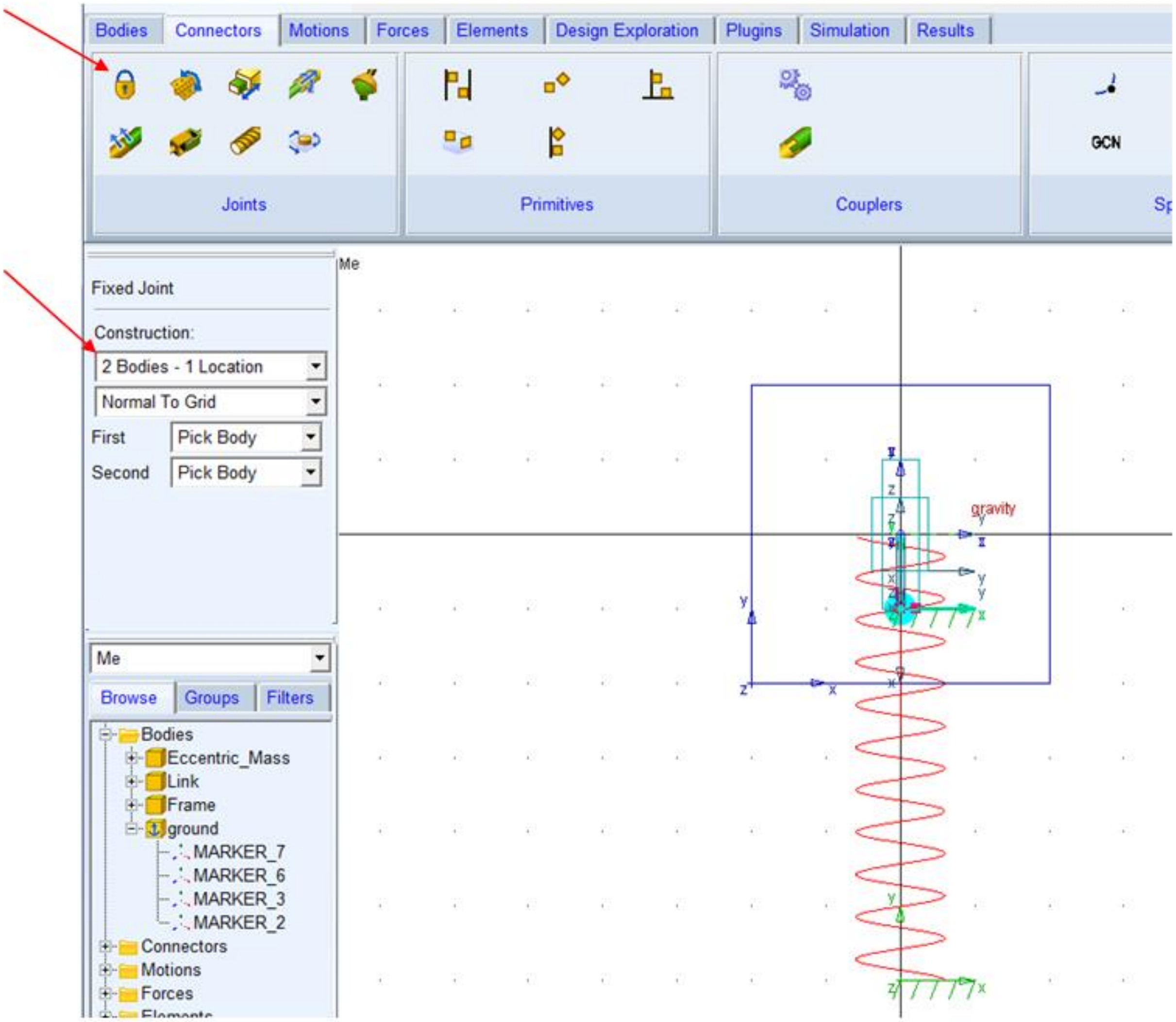
26- Create a "Sphere" with radius=10mm at the end of the "Link".



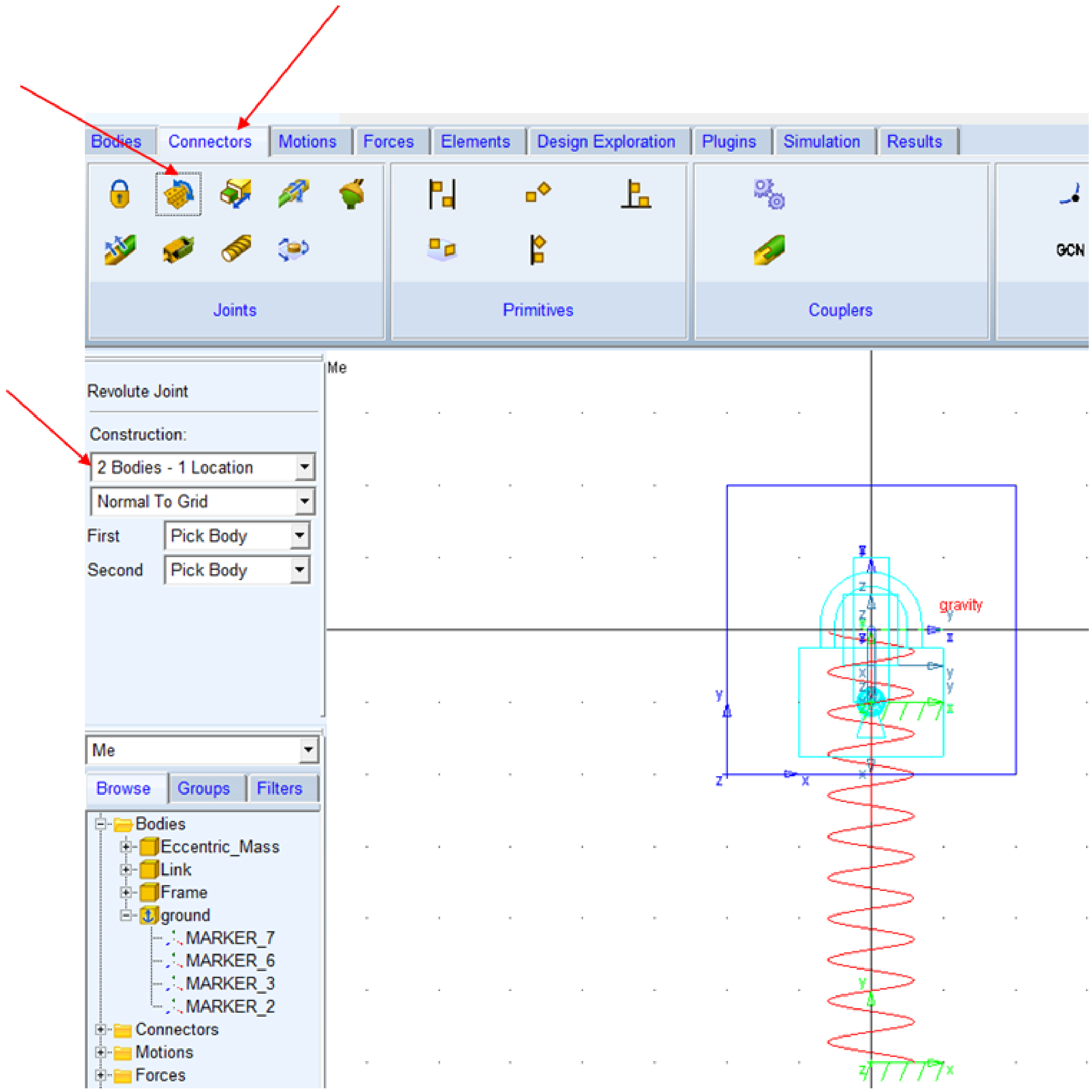
27- Rename it to "Eccentric_Mass".

28- Modify its mass to 0.03Kg.

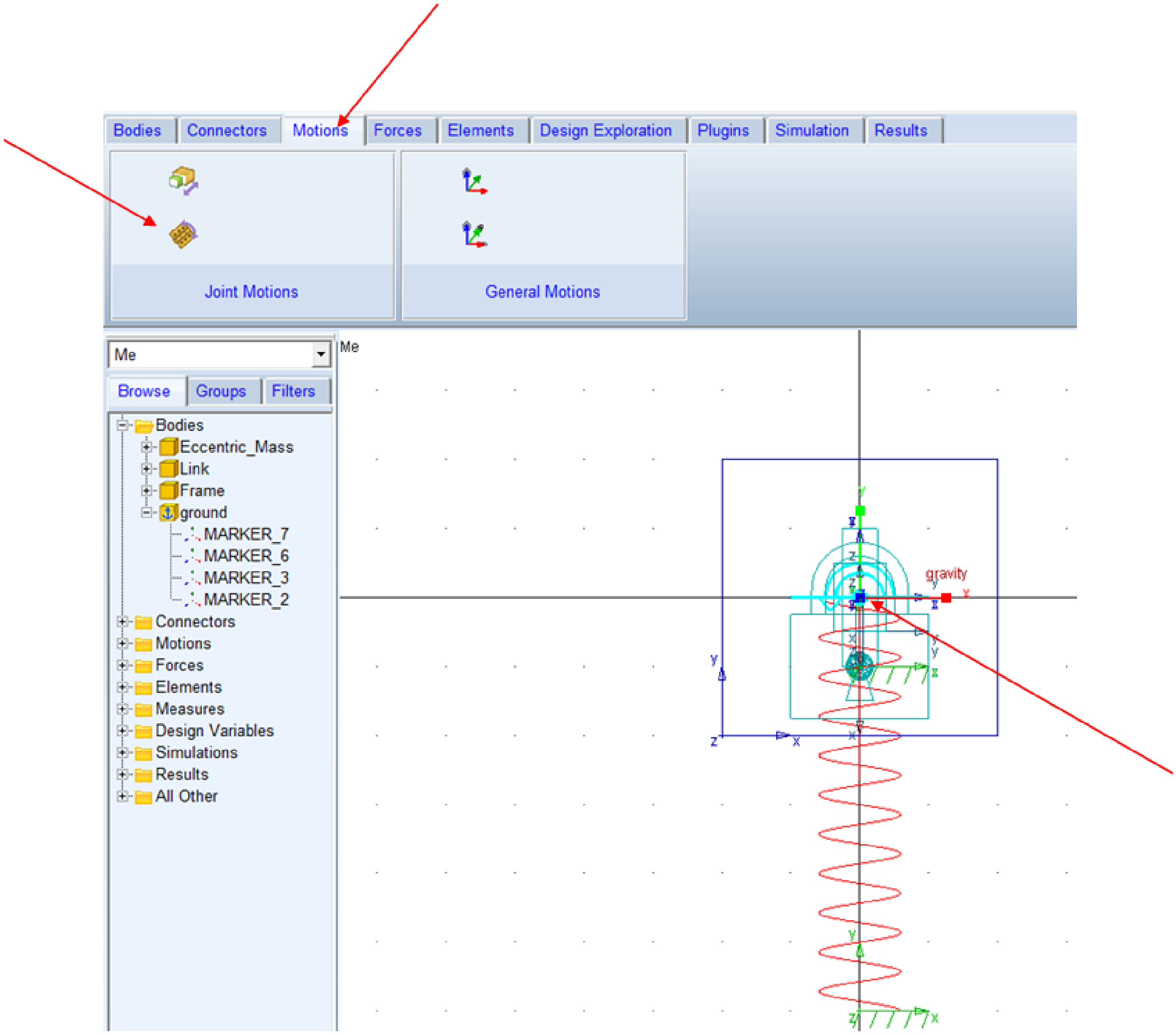
29- Connect the "Eccentric_Mass" and the "Link" together by: from "top menu" select "connectros" and then choose "Fixed Joint". (Joint them at the c.m. of " Eccentric_Mass".



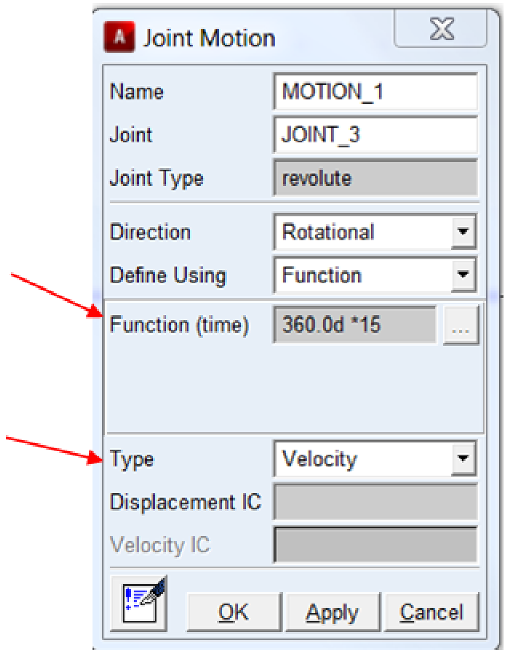
30- By a "Revolute Joint" from the "Top menu" select "Connectors" and then select the "Revolute Joint" try to join the "Link" and the "Frame" at the Frame.cm



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.

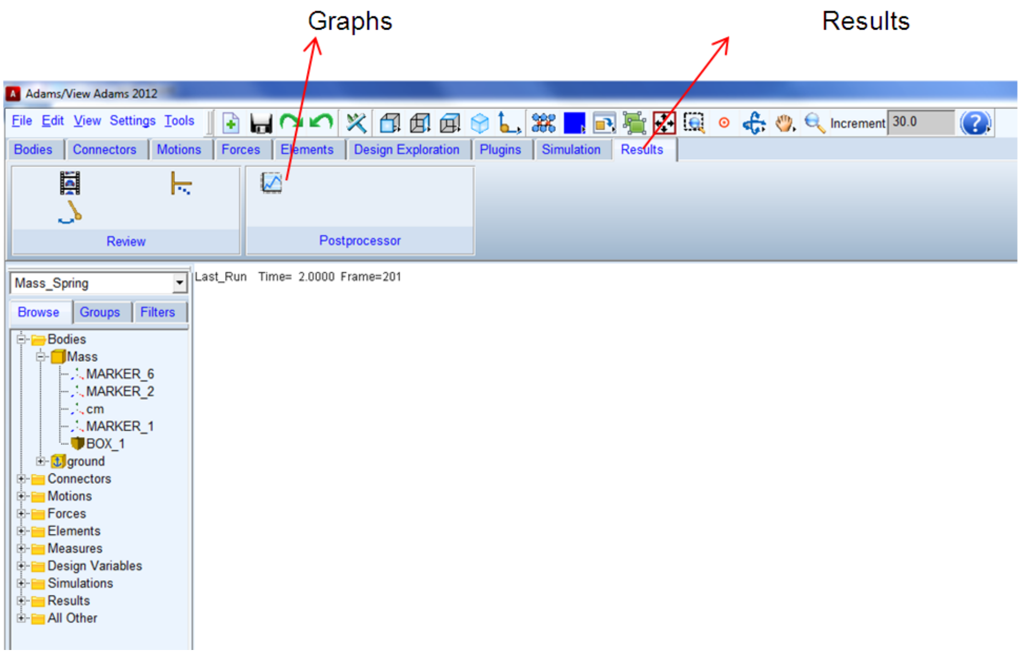


32- Right click on the "motion" you just created and modify it as the following window: (change the type to "Velocity" and the Function (time) to a constant speed of 360d*15) (note that since the unit we chose at the beginning was degree, the rotation speed is degree/second; so we have to add 360d. In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

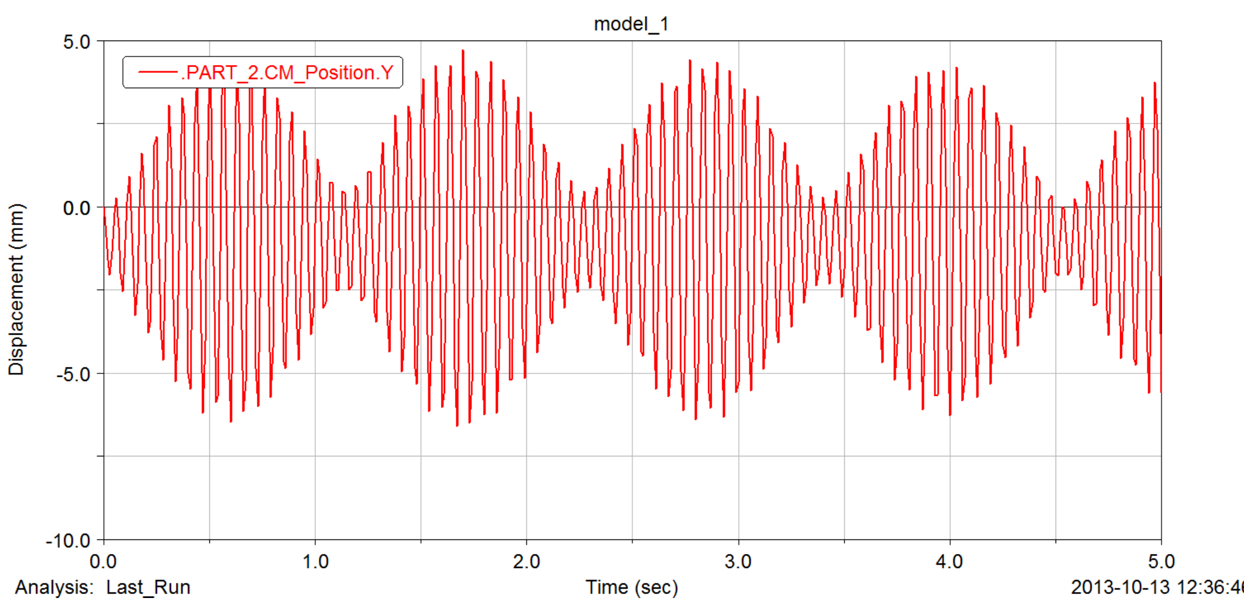


32- Run a simulation: 5Sec, with 5000 steps

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, …)



Assignment:

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

hint: Compute the damping for an under-damped situation (just try an arbitrary , $\zeta < 1$); critical damping ratio ($\zeta = 1$) and an over-damped situation; and try these damping coefficients in your model and compare the vibration of the main system with and without damping at a resonance case (i.e. the system is rotating at the rotation speed about the natural frequency of the system).

Write a short repost including the damping computation for the system, and add the graph of displacement of the main system in Y direction with and without damping at 4 different rotating speeds (This system works in the range of **600-1500rpm**):

1- Below the critical speed (resonance rotational speed)

2- At the critical speed

3- Above the critical speed

4- At the beating rotating speed

In total you'll produce 4 plots (1-4 simulations) and each figure contains 3 graphs (under, over and critical damping)

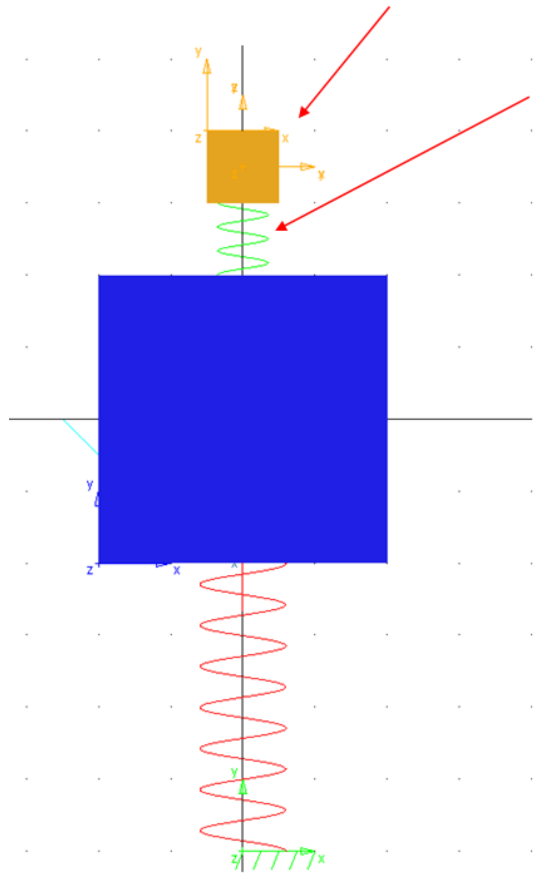
Evaluate your design (the damping coefficient) carefully and finalize the damping coefficient that you prefer to choose for this system to minimize its vibration.

Email a PDF file (a complete report of your computations, the graphs; if you have tried different damping coefficients for the system then the results for that; and the results of your evaluation of the vibration of the system at different rotation speeds) to ahmadpa20"gmail.com **before the start of your next ADAMS class.**

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)

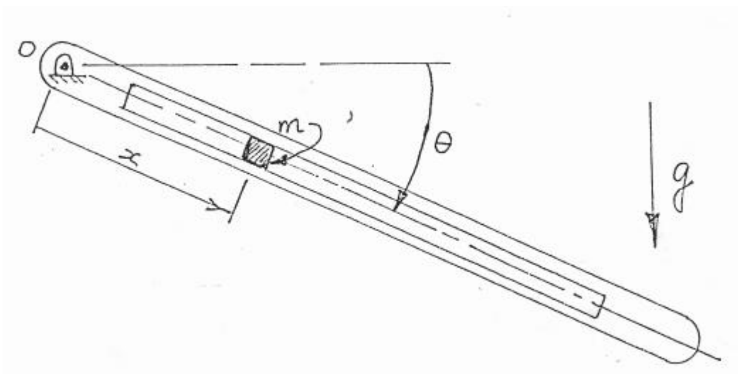


Chapter 3

Sliding Mass on a Rotating Bar

Problem Description

We will be modeling a long rod, and a small mass, m, able to slide on the rod. Sliding of the mass is opposed by friction ($\mu_s, and\ \mu_k$). The rod is pinned to the ground; and angular motion about this point is controlled by an electric motor which produces a constant angular acceleration of the rod ($\ddot{\theta}$)



m = 1 kg, $\boldsymbol{\theta(0) = 0}$, ***X(0)=0.2m,*** $\boldsymbol{\mu_s = 0.3, \mu_k = 0.25, \ddot{\theta} = 0.4\ rad/s^2}$

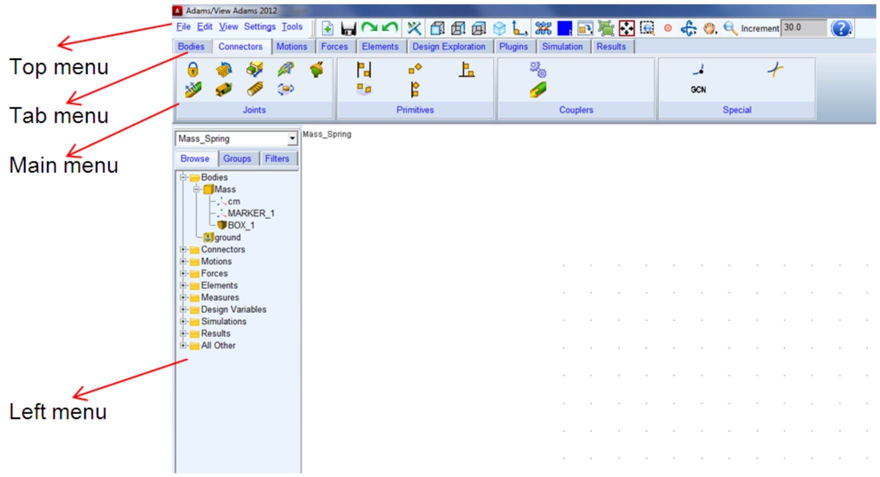
Starting ADAMS:

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

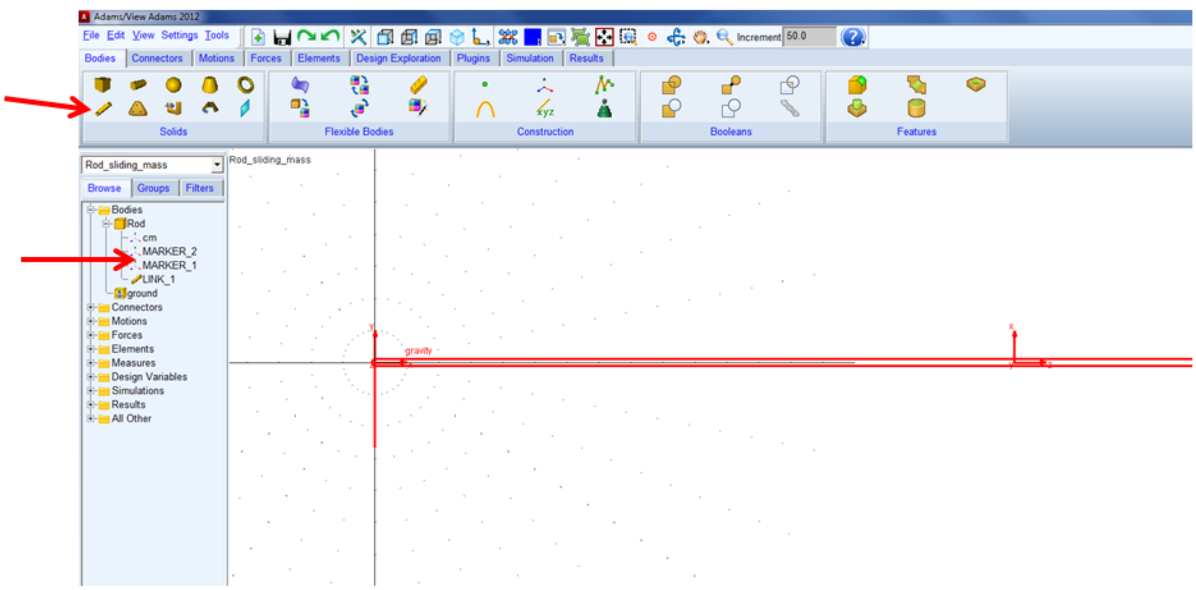
4- From top menu/settings/ coordinate, select your desire coordinate (you'd better choose "Cylindrical" for this problem);



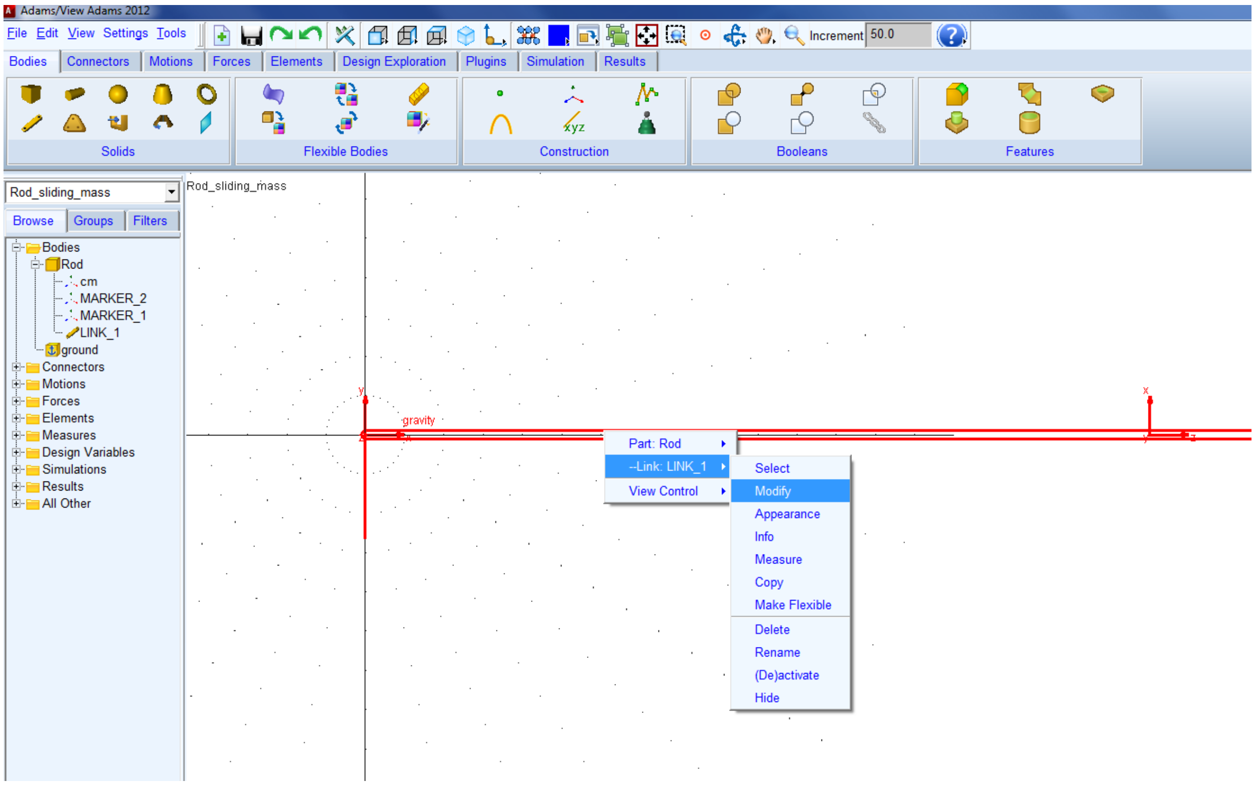
5- From top menu/settings/ units, select your desire units.

6- Verify the Gravity

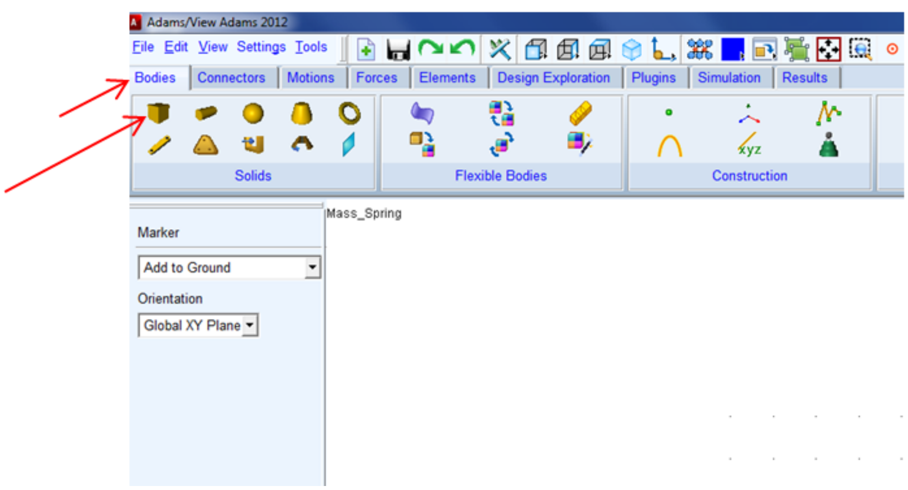
7- Create a Rigid-Link; then modify its 2 ends maker: Marker_1 = 0,0,0 Marker_2= 4000mm,0,0



8- Modify Link (right click on the link, choose –Link_1, then choose modify); then modify Width=10mm; and Depth=10mm



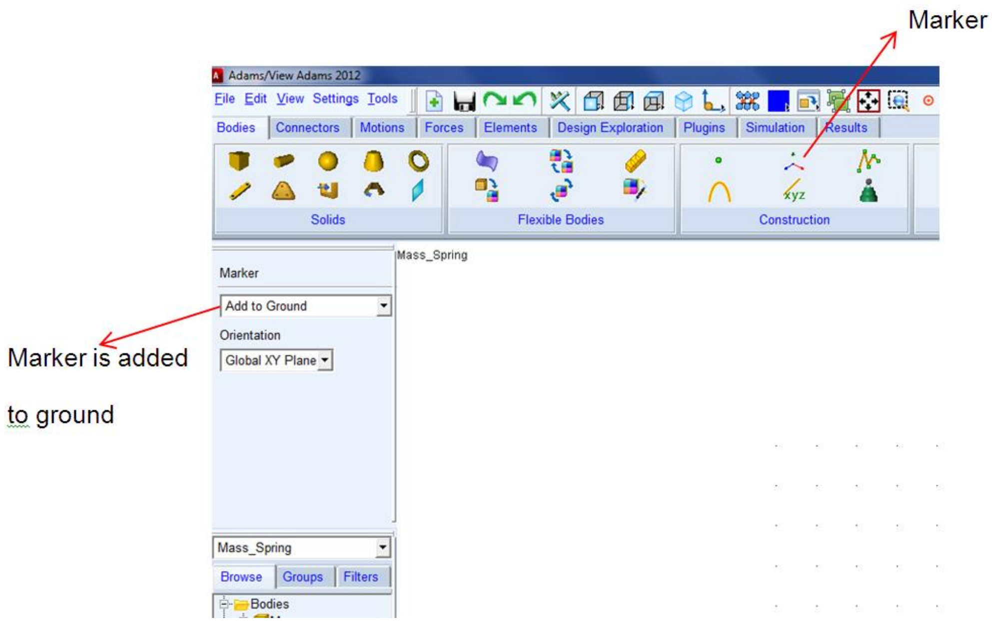
9- Create a Block: choose Tab menu/Bodies, and select Box (use mouse, hold left click, drag and release with arbitrary size)



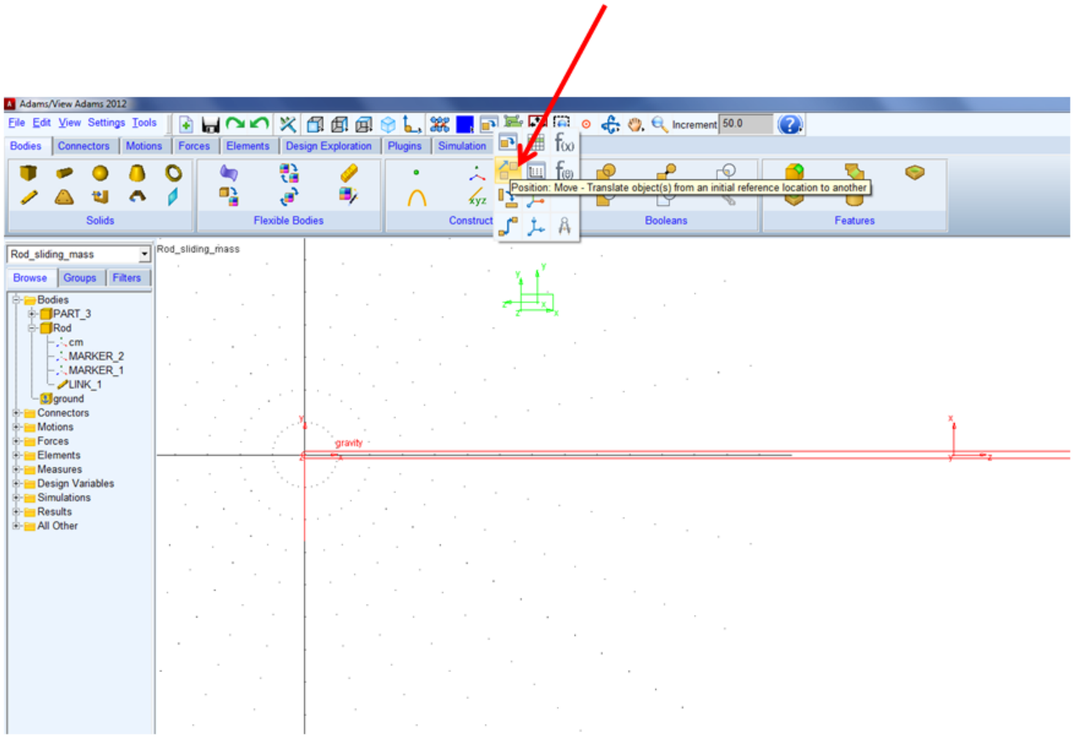
8- Right click on the block/Part, and change its name to “Mass”

9- Right click on the block/Box, and modify its length, height, and width (50,25,25mm)

10- From Tab menu select Bodies, then from main menu select “marker”; (**add to Part**) then choose the Rod, by clicking on that . Then right click somewhere on the Grid, and modify the Marker location to: 200,0,0(right click on the marker, then modify)



11- Now, movie the block to this marker. First select the Below Icon; then from left menu choose : “From To” and follow the instruction appears in the prompt menu. (try to move the block, from its cm to the marker you created in step 10)



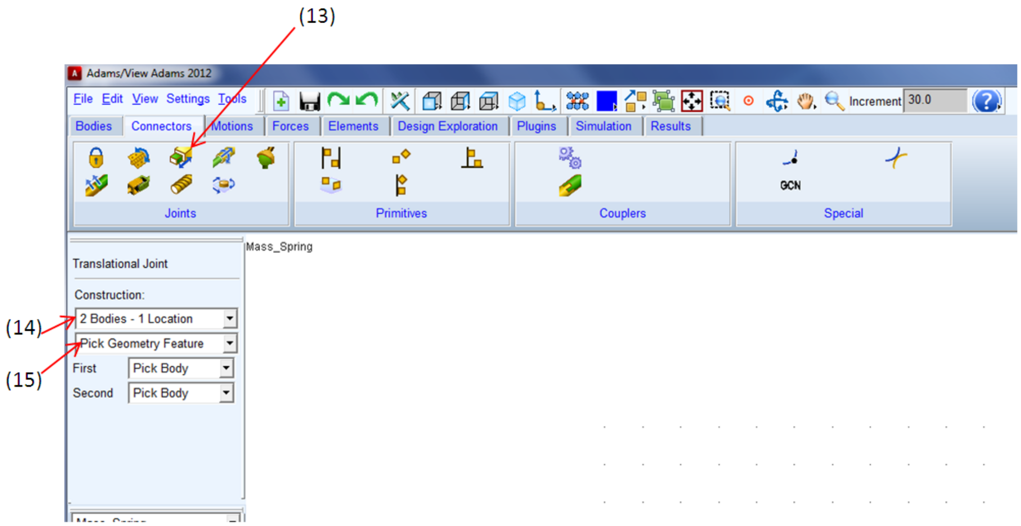
11- Check the cm (center of mass). is it at the 200,0,0?

12- Right click on the created block, and choose Part: Mass/Modify ; then choose “Mass Properties”; and “User Input”. Let mass be 1 Kg and all moment of inertia 0 (Later try to run the same simulation but with the moment of inertia not to be zero)

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

14- Select “2 Bodies-1 Location”

15- Select “Pick Geometry Feature”



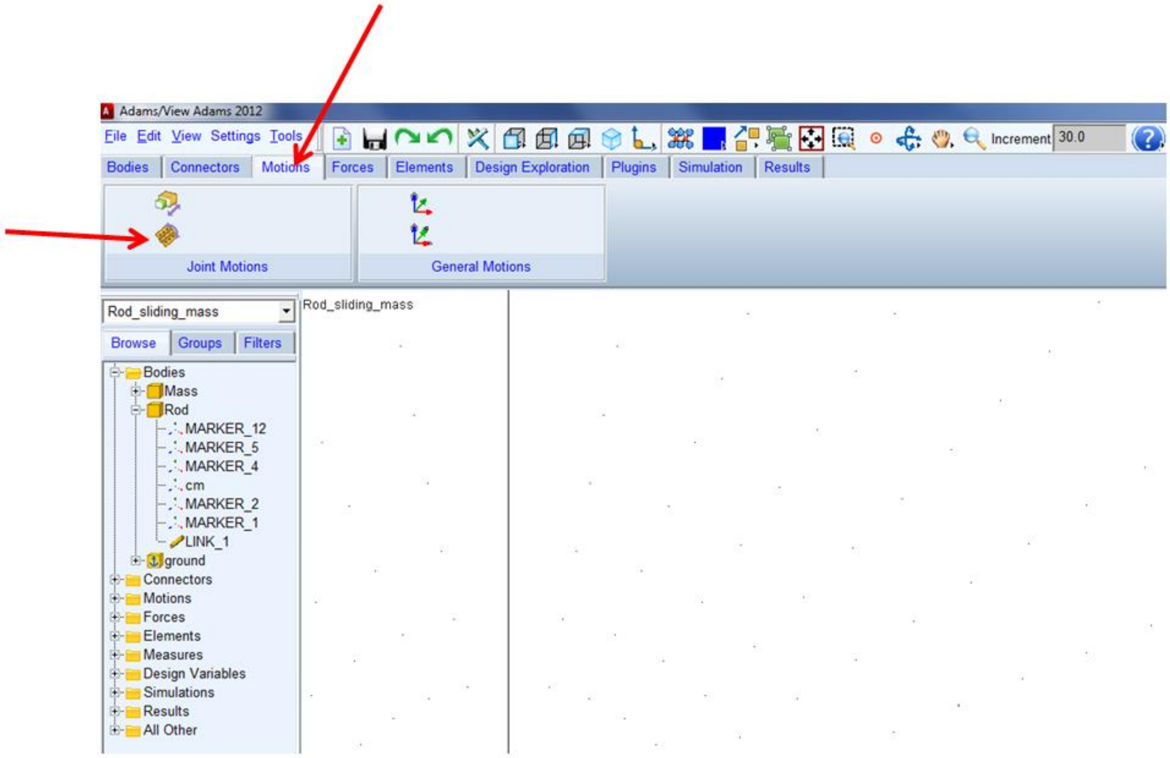
16- Select the Mass, then click on the Rod, and then select the "Mass.cm", and choose the direction vector.

17- Now create a revolute joint, between Rod, and ground. (normal to the Grid; and the 0,0,0)

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

19- From tab menu choose motion:

20- then select Rotational joint Motion:



21- Select the "Revolute Joint you created.

22- Right click on the motion you created and modify it to: Type = Acceleration

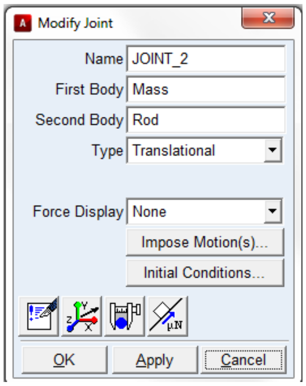
And enter in Function (time) = 0.4

23- Run a simulation for 2 sec, 200 steps

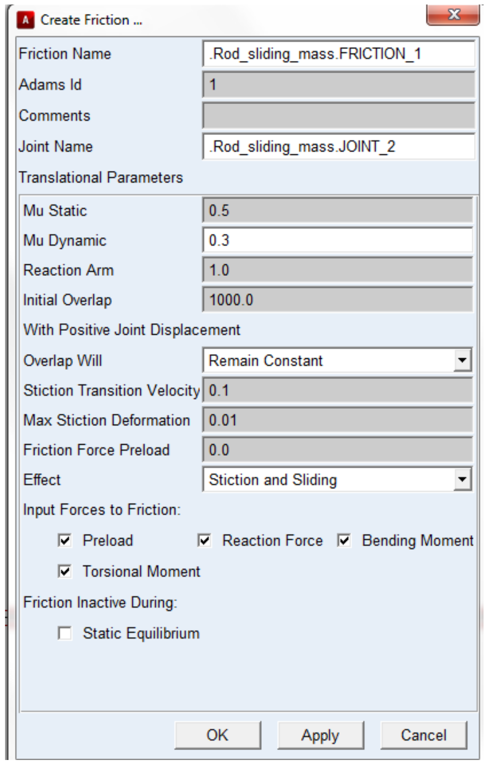
Oops! What does happen? Shouldn't the motion be -0.4 (Why?)

24- Right click on the "Translational Joint" and select Modify.

25- Select the following Icon



26- This window should appear:



27- Change just Mu Static, and Mu Dynamics (later you will discover other controlling parameters on your own); and then Apply or Okay to close this window.

28- Run a simulation for 2.5 seconds, 2500 steps

29- Go to “Results” (Tab menu); and “Postprocessor “

30- Create Mass, Cm position graph (R) as function of time

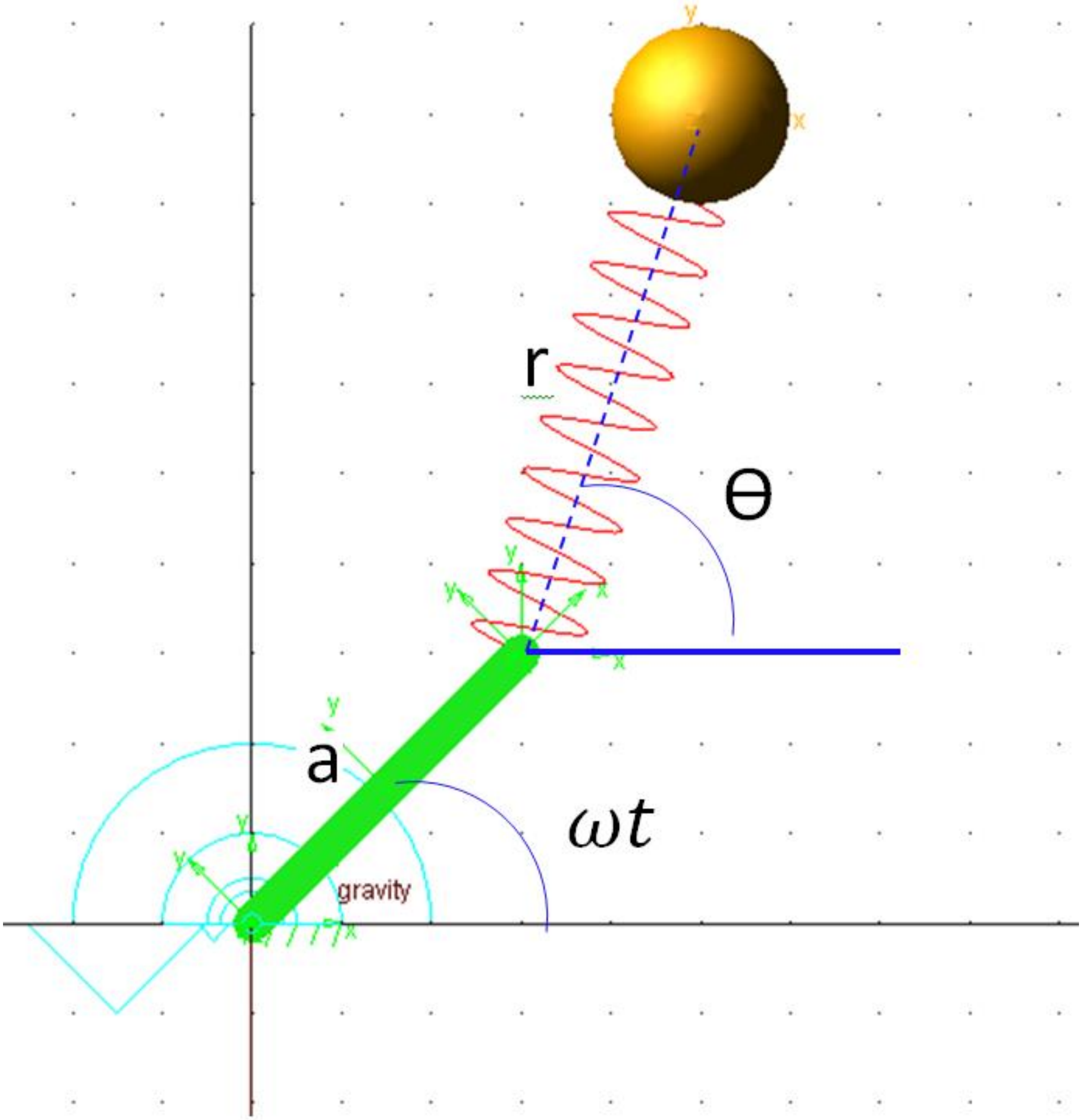
30- Create Mass, Cm position graph (R) as function of Theta

31- Create Force (total) as function of time, and theta (investigate the results)

32- Enjoy, producing other results that are available for you in Postprocessor!

Assignment: Chaotic Pendulum:

You will try to model the following pendulum. (The motion is on the plane, so De-active Gravity)



Analytical Study:

Hint: try to find the equations of motion using Lagrange method:

Kinetic and Potential Energy:

$$T = \frac{1}{2}m\dot{r}_p{}^2 + \frac{1}{2}m\dot{\rho}^2 + \dot{r}_p.m\dot{\rho}$$
$$= \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) + \frac{1}{2}ma^2\omega^2 + ma\omega[\dot{r}\sin(\theta + \omega t) + r\dot{\theta}\cos(\theta - \omega t)]$$

$$V = \frac{1}{2}k(r - r_0)^2$$

Therefore Lagrange function is:

$$L = T - V = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) + \frac{1}{2}ma^2\omega^2 + ma\omega[\dot{r}\sin(\theta + \omega t) + r\dot{\theta}\cos(\theta - \omega t)]$$
$$- \frac{1}{2}k(r - r_0)^2$$

Using Lagrange method, we obtain:

$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{r}}\right) + \frac{\partial L}{\partial r} = 0$ and $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\theta}}\right) + \frac{\partial L}{\partial \theta} = 0$

$$m\ddot{r} - mr\dot{\theta}^2 - ma\omega^2 cos(\theta - \omega t) + k(r - r_0) = 0$$

$$mr^2\ddot{\theta} + 2mr\dot{r}\dot{\theta} + mar\omega^2 sin(\theta - \omega t) = 0$$

$$\ddot{r} - r\dot{\theta}^2 - a\omega^2 cos(\theta - \omega t) + \frac{k}{m}(r - r_0) = 0$$

$$r\ddot{\theta} + 2\dot{r}\dot{\theta} + a\omega^2 sin(\theta - \omega t) = 0$$

Check the equations ?

First write a MATLAB code for solving the above equations. Then try to model the system in ADAMS.

Check ADAMS results for some certain points, and the results you will get from the above equations of motion.

(**Optional:** Repeat your simulation with “Gravity”)

Plot:

1- "r" as function of θ for a given ω

2- "r" as function of ω during a run up of ω from 0-600rpm.

Compare your Numerical results with ADAMS results.

Email a PDF file (a complete report of your computations, the graphs; for the system with the physical properties that you choose.) to ahmadpa20"gmail.com **before the start of your next ADAMS class.**

Chapter 4

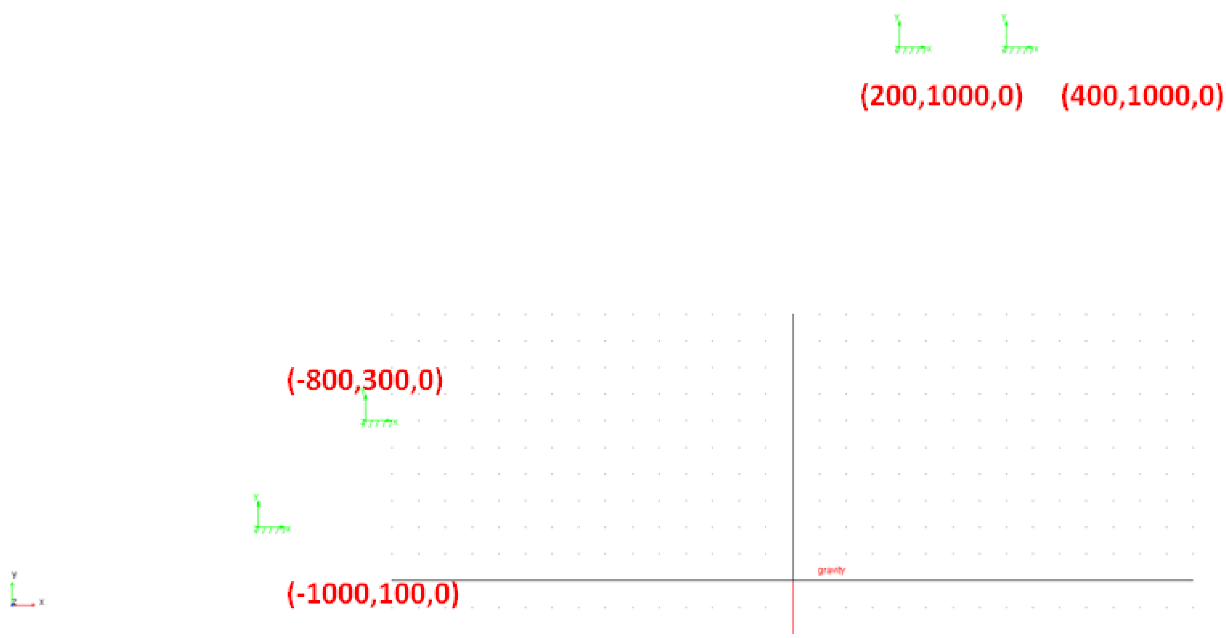
Contact Modeling

Problem description:

We will be modeling a simple impact of 2 objects.

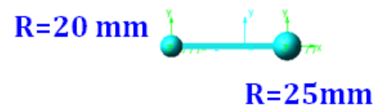
1- De-activate the gravity

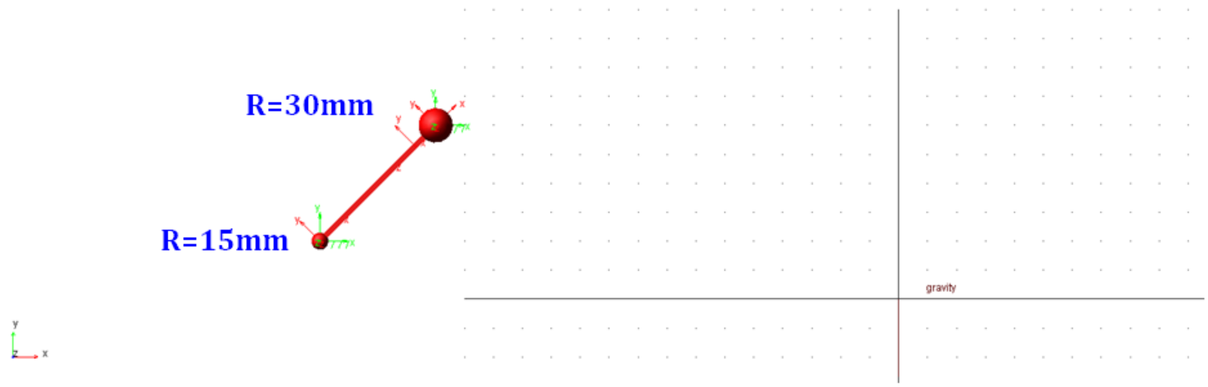
2- Create the following 4 markers (Unit mm)



3- Create 2 bars like the next figure (Modify width=10mm and depth = 10 mm)

4- Create the following spheres with the center at the end of bars.





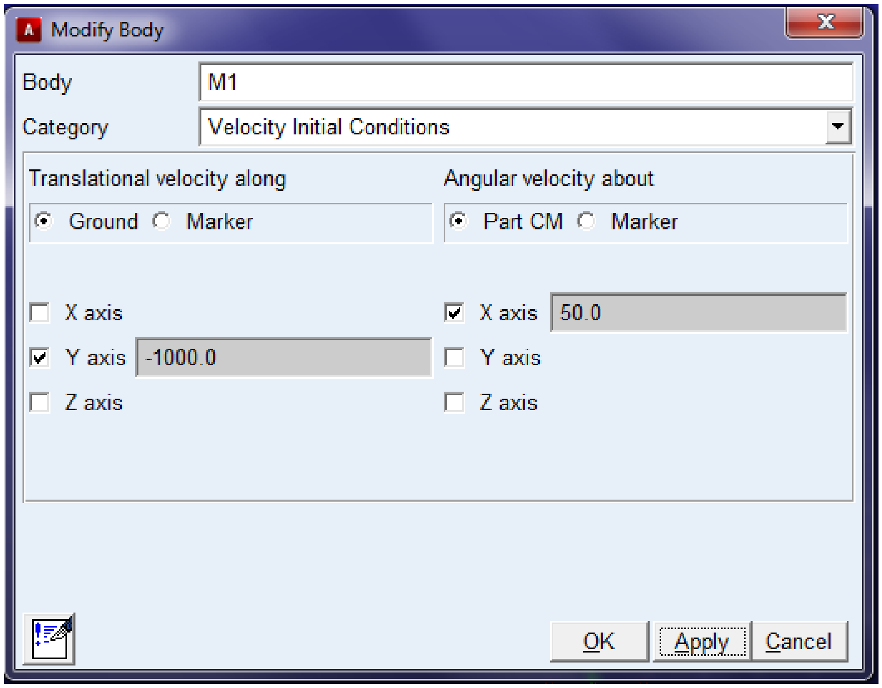
5- Attach the spheres to the bars.

6- Rename the two parts to M1 (the upper one) and M2.

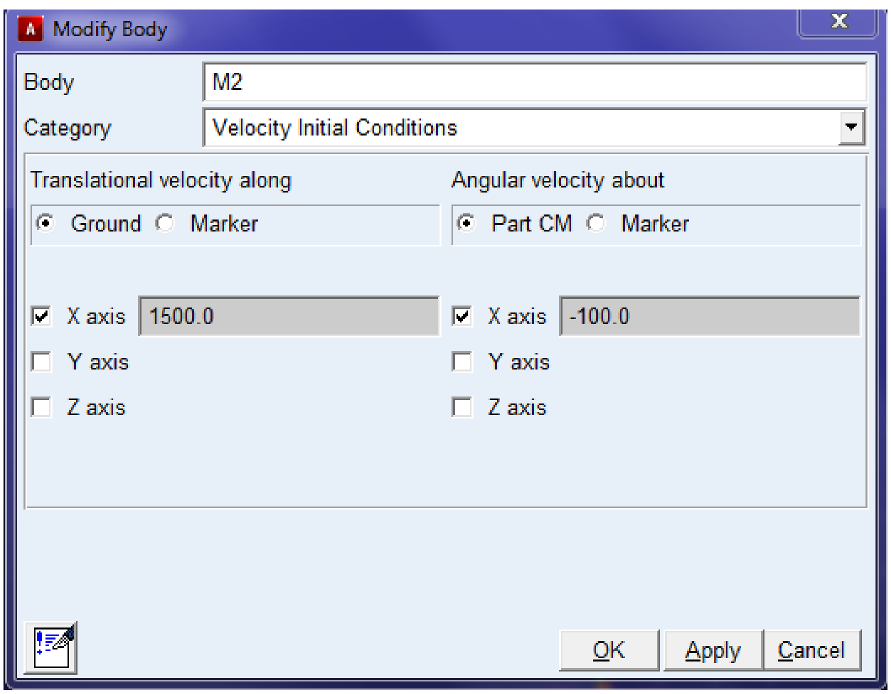
7- Take a look at the mass and moment of inertia for M1 and M2. (You can latter calculate them based on the geometry and the density: $\rho = 7800\,Kg/m^3$)

8- Right click on M1 and M2. Choose Part: M1 then Modify; and from the window (like below) choose “Velocity Initial Conditions)

Initial Linear and Angular Velocity of M1

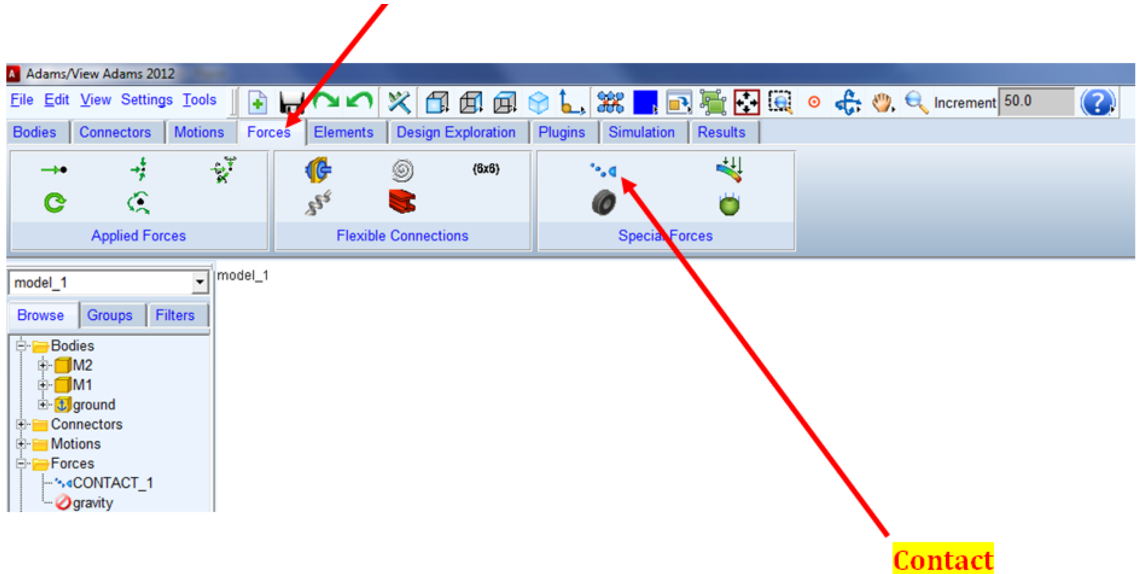


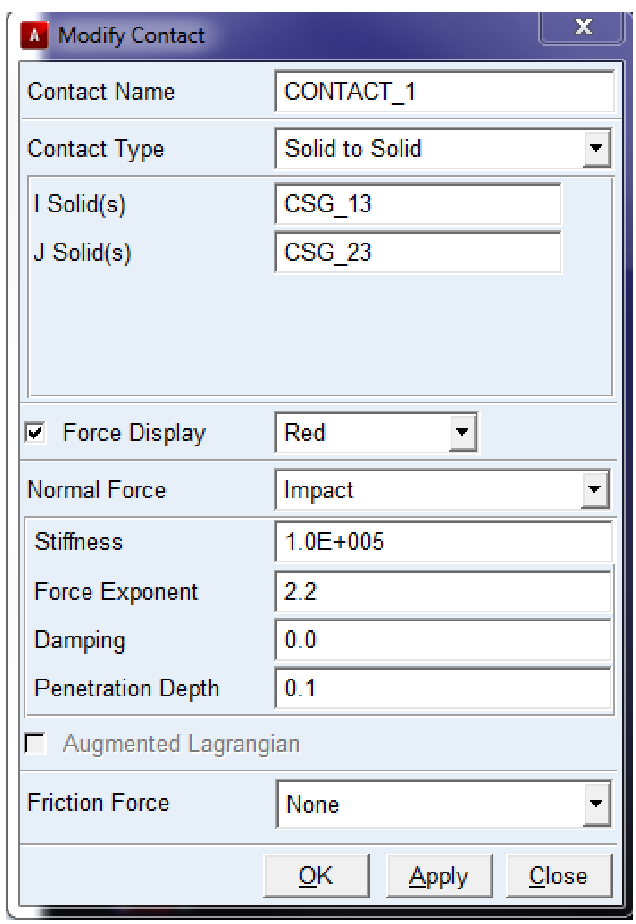
Initial Linear and Angular Velocity of M2



9- Run a simulation; and observe what happens.

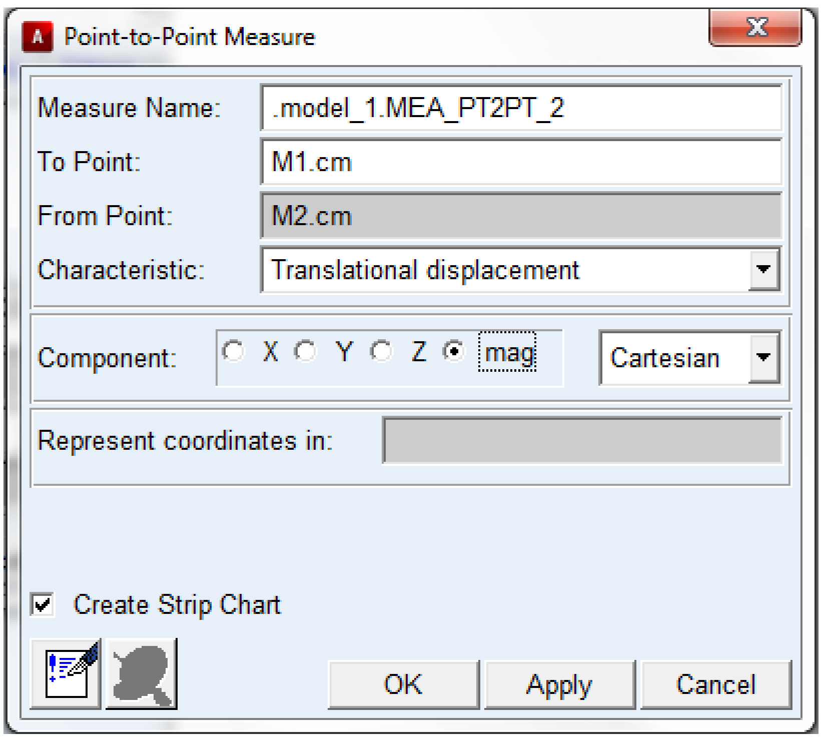
10- From the “Tab Menu” select “Forces”; then select “Contact” and Modify the numbers as the following:





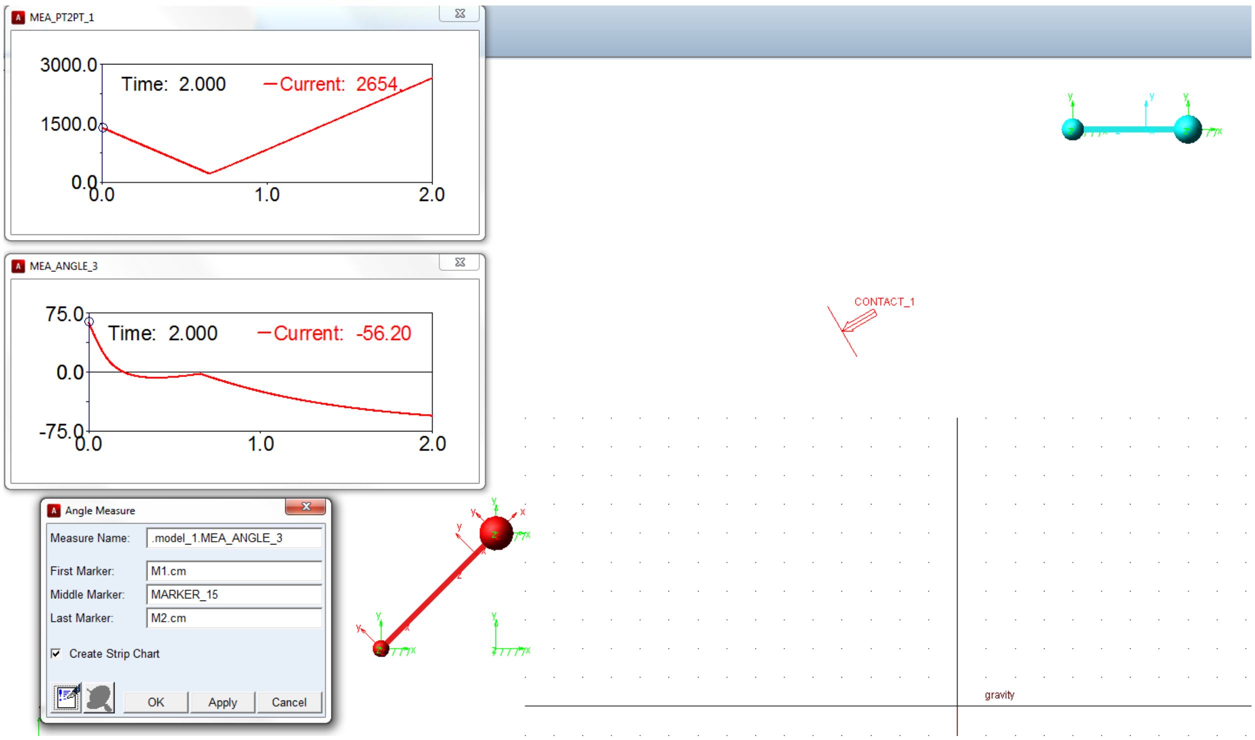
11- From “tab menu” select “Design Exploration” and then choose “point-to-point measure”

12- Choose “Advance” and in the window like below: select the M1.cm and M2.cm as to point you are interested to measure their distance. Select “mag” (magnitude)



13- Create a marker at (-800,100,0)

14- Then from “tab menu” select “Design Exploration” and then choose “Angle Measure”; select “Advance” then pick the M1.cm as the “First Marker” ; The marker you just created in step.. as the “Middle Marker” and the M2.cm as the “Last Marker”



15- Run a simulation for **2 sec. 1000 steps**

16- In “postprocessor” plot the “measures” you just created.

16- Plot M1 and M2 c.m. (center of mass) position in X and Y direction all in one graph.

17- Plot M1 and M2 c.m. (center of mass) Velocity in X and Y direction all in one graph.

18- Plot M1 and M2 Angular Velocity all in one graph.

19- Plot Contact force. Try to figure out the duration of impact by zooming on Time axis.

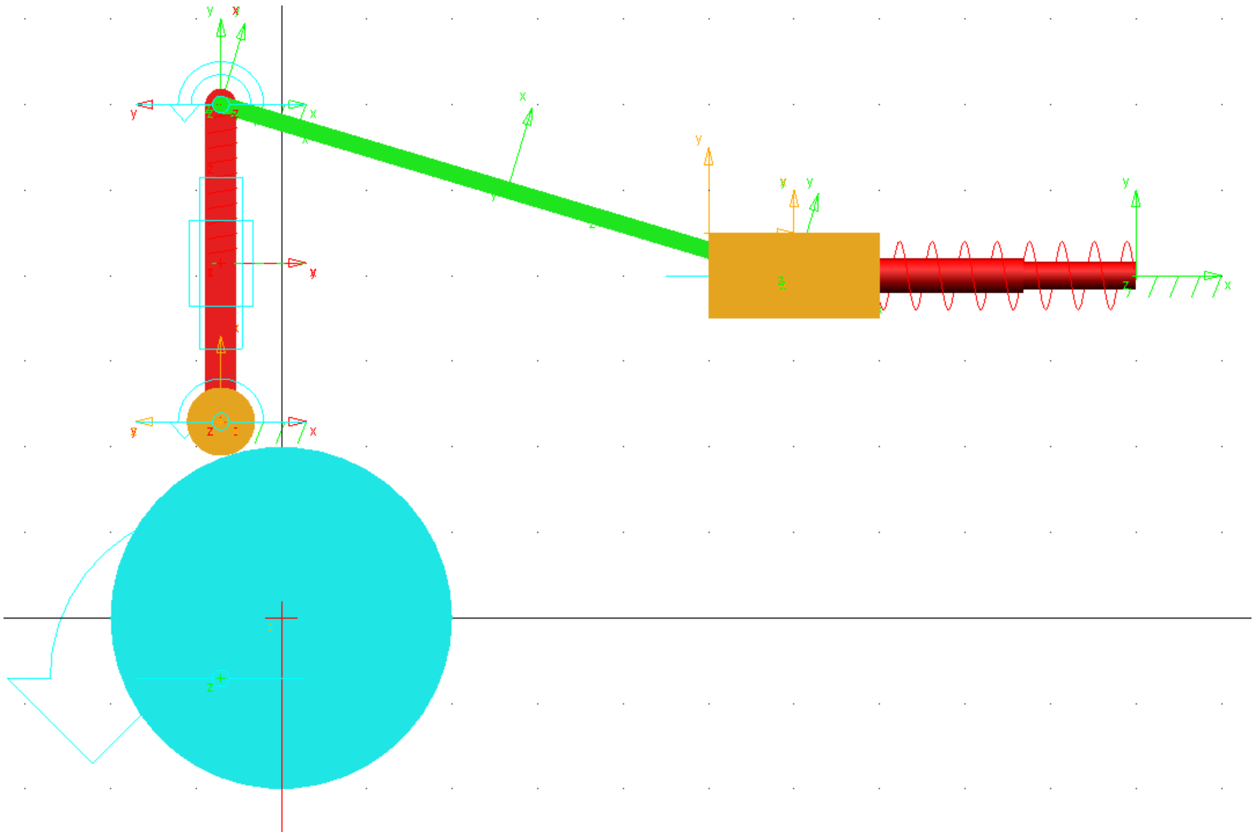
20- Interpret the results.

Assignment:

You will be designing a cam mechanism like below. Geometry modeling of the mechanism consists of 2 “Extrusions” with circle section; 2 “Bars”; and 1 “Box”. Then by “Revolute Joint” and “Translational Joint” you can assemble the mechanism. You can add 2 springs to your model (one for the vertical bar and another for box in horizontal direction. At the end you create a “contact” between 2 parts of cam mechanism.

From what you have learned you should be able to build this model.

Be creative and imagine you are designing a cam mechanism from scratch. Select a given size and load; then tests how mechanism works. And then by optimizing the springs, or the weight of parts check if the mechanism works for your desire rotation speed. (*i.e.* there shouldn’t be any “jumping phenomenon” in the cam. After it works properly, consider “Friction” in all joints. And also consider friction in “Contact”. Evaluate your mechanism.



Email a PDF file (a brief explanation of your model, its physical properties, , A graph that shows the motion of the horizontal block as a function of rotation speed of the cam 0-600 rpm.) to ahmadpa20"gmail.com **before the start of your next ADAMS class.**

Chapter 5

The Motion of a Spinning Disk with Eccentric Hole

Problem Description:

You will be investigating the flipping of the center of mass in a disk with a hole in it:

First watch the following videos on YouTube:

1- http://www.youtube.com/watch?v=h0SZZTBQmEs

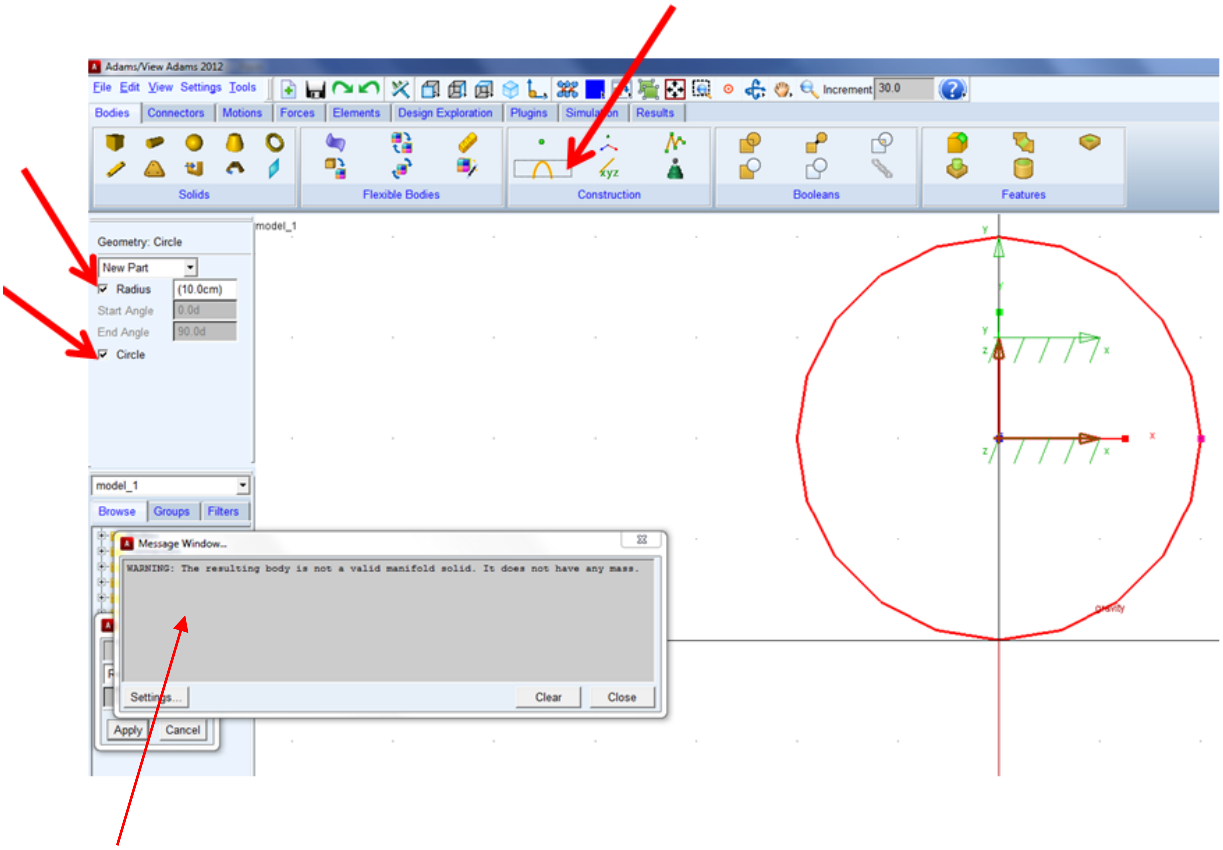
2- http://www.youtube.com/watch?v=tDr26U49_VA

Modeling the Problem:

1- Set up the units, gravity, …

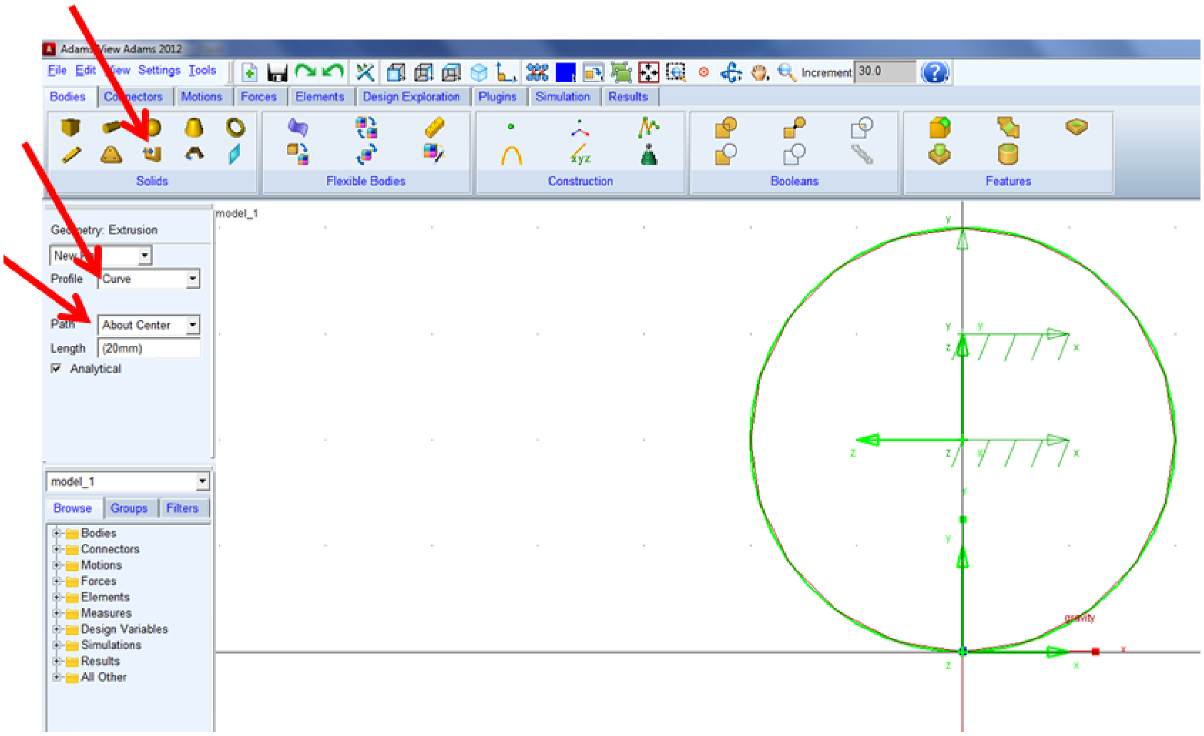
2- Create 2 Markers (add to the ground) at Marker1= (0,100,0), and Marker 2= (0,150,0) mm

3- Using the “Construction” create a circle with Radius=100mm, and center at the Marker1



Read the warning! (Can you think of why?)

4- Use the "Extrusion" icon, change the "Profile" to "Curve" , then "Path" select "About Center" and select the "thickness" to 20mm (or 2cm) be careful about the unit! Then pick up the circle you just created.



5- Use 3D view, or rotate the object to observe what you have created!

6- Create a circle with Radius=30mm, and center at Marker 2.

7- Create a cylinder exactly like step 4 with the circle you just created, with "Thickness=30mm (be careful when you are asked to pick up the "profile" you must select the "circle you just created because the first circle is still there.)

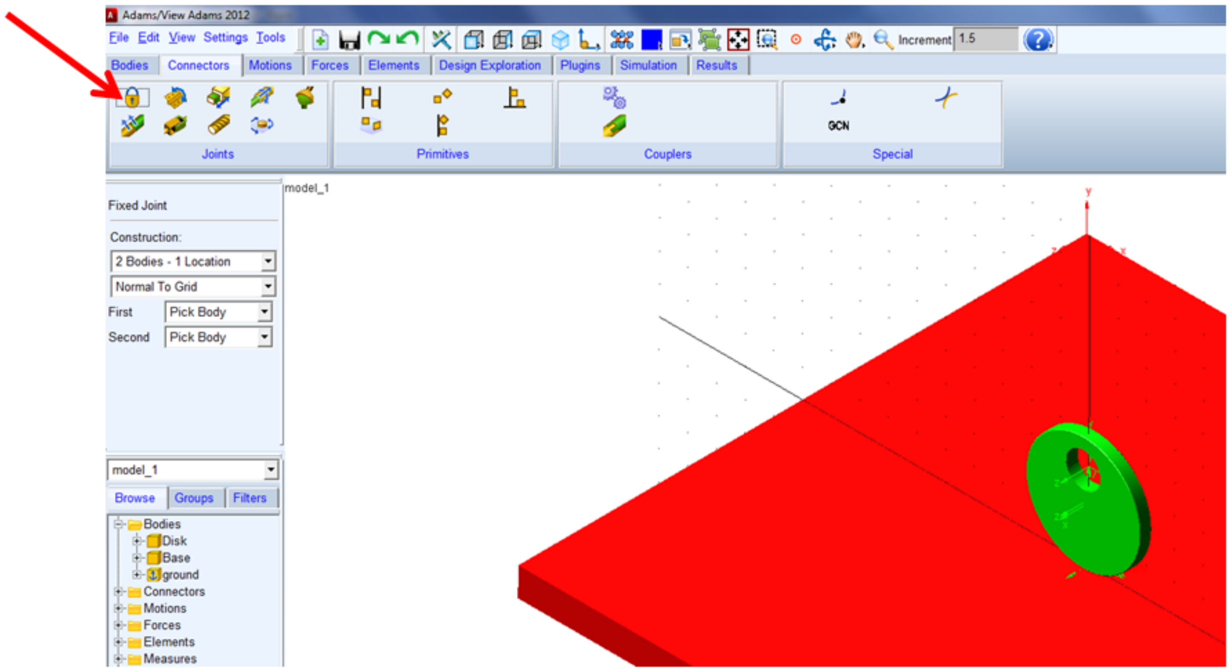
8- Now, using Boolean operations cut the big cylinder by the small one. (follow the instruction bellow the window to avoid mistakes for choosing the cutter part and the part is going to be cut!)

9- Rename the part to "Disk"

10- You might want to "fillet" the outer edge of the disk to have a nice, smooth shape disk! (Fillet Radius= 1mm)

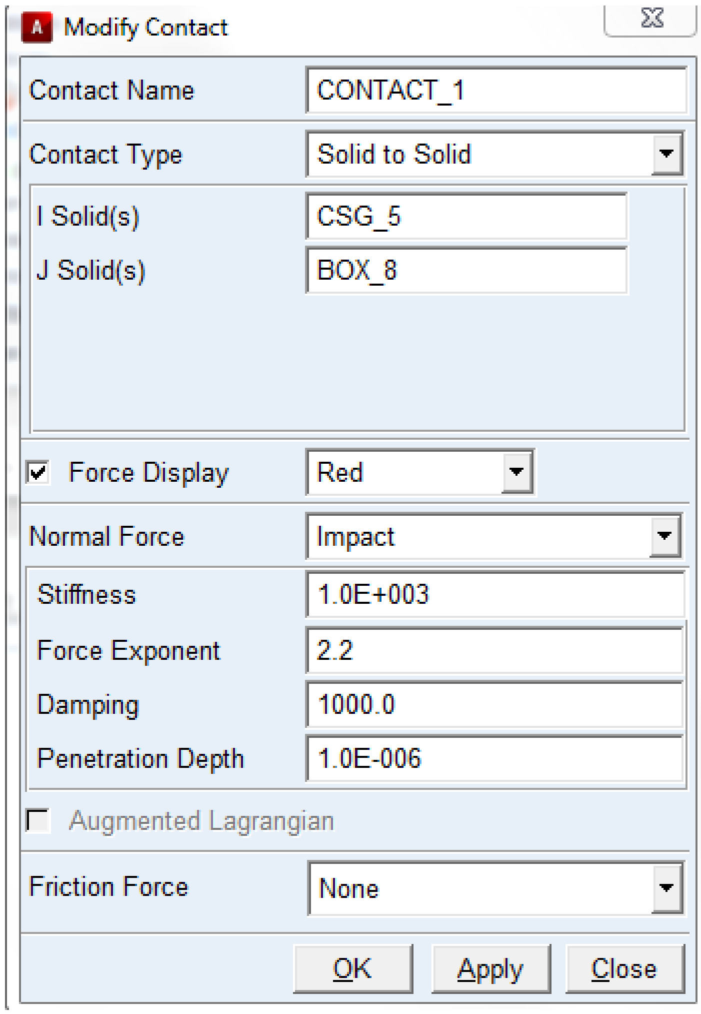
11- Create a Box, and Modify its corner Marker to (-500,0,-500); then modify the length, thickness, and width of the box to (1000mm), (-50mm), (1000mm). (In fact we are creating a base, so we can play with the disk on it!) You might want to rename this box to "Base" or whatever!

12- Fix the "Base" to the ground using the " Create a Fix Joint" (it doesn't matter which point of the Base you fix to the ground, since the Base is "rigid")



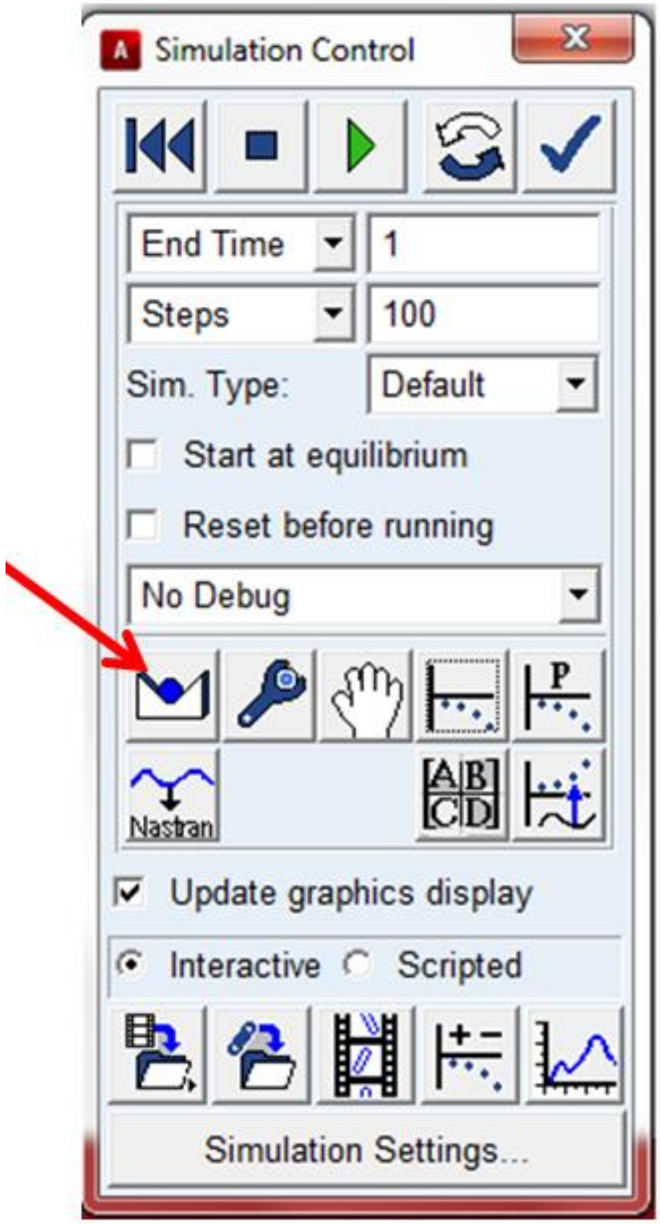
13- Run a simulation, just for fun! (1sec, 100 steps)  So you need to create "Contact" !

For now select the following parameters!



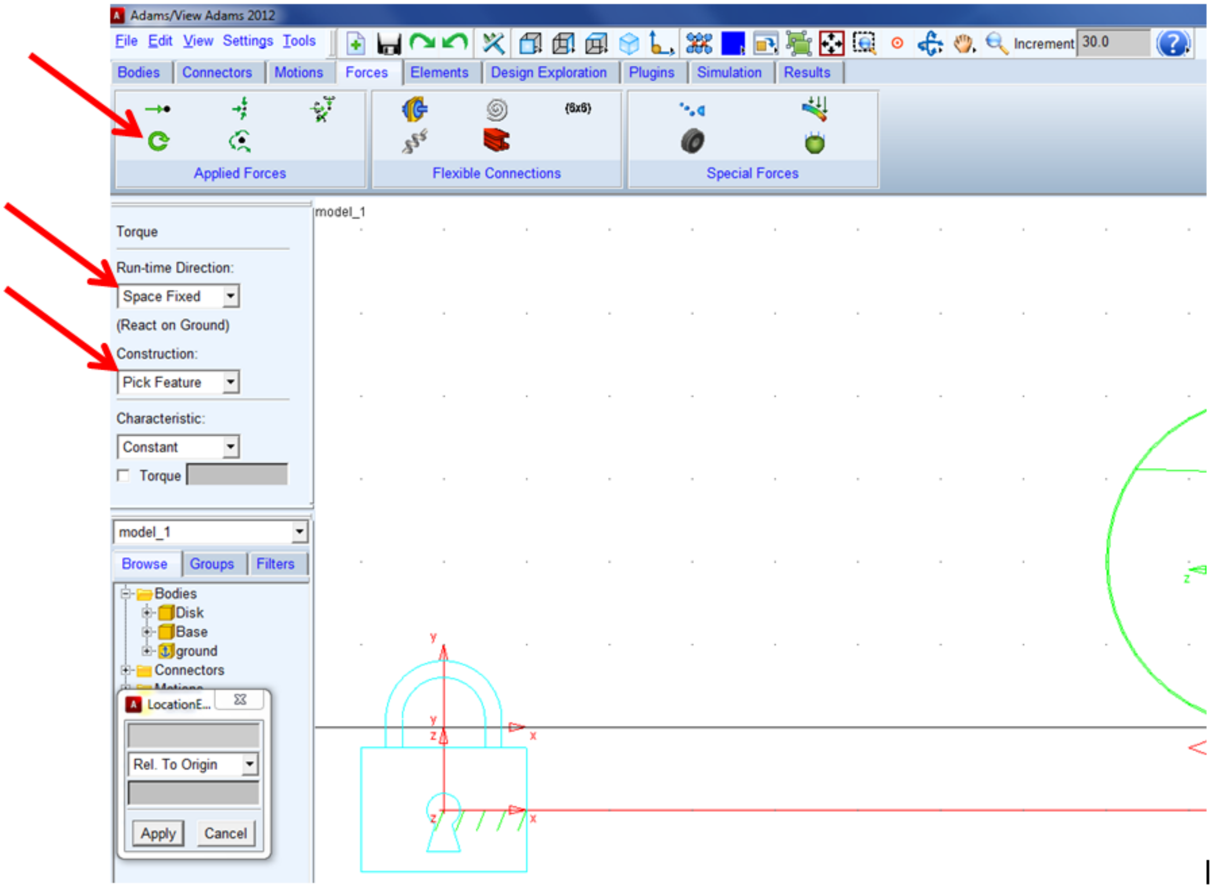
Latter if you wish; check the "ADAMS/View Help" then search "Contact" and read through what are these parameters and how program solve a contact problem.

14- Run a simulation, and "Find the static equilibrium"



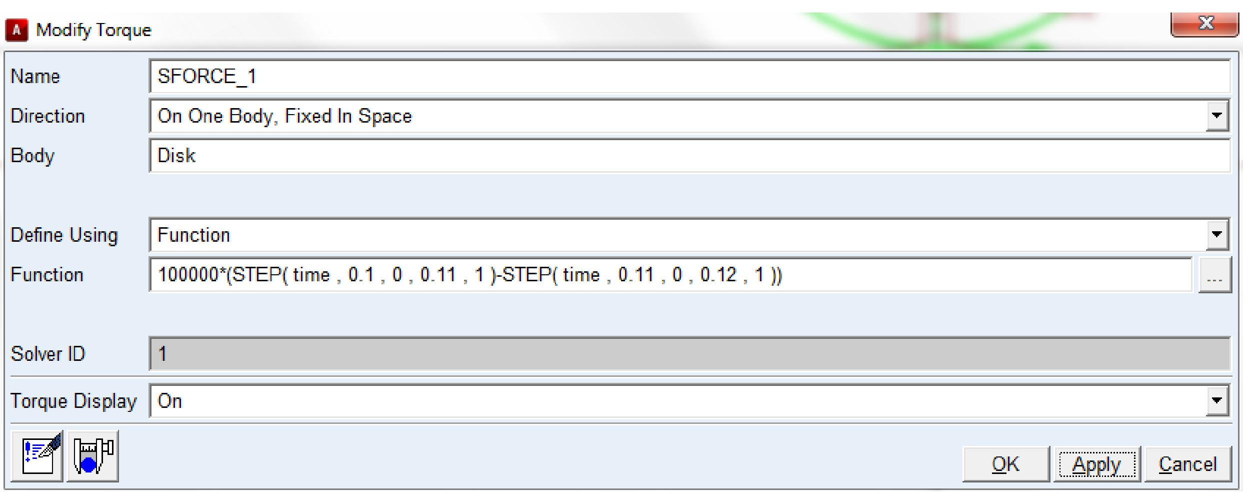
15- Create a Marker, Attached to the Disk, at (0,190,0)

16- Create a "Torque" : Run time Direction: "Space Fixed" , Construction: "Pick Feature" follow the instructions at bottom of the window; select the Marker you just created in step 16 for the point to apply the torque. And the direction vertical

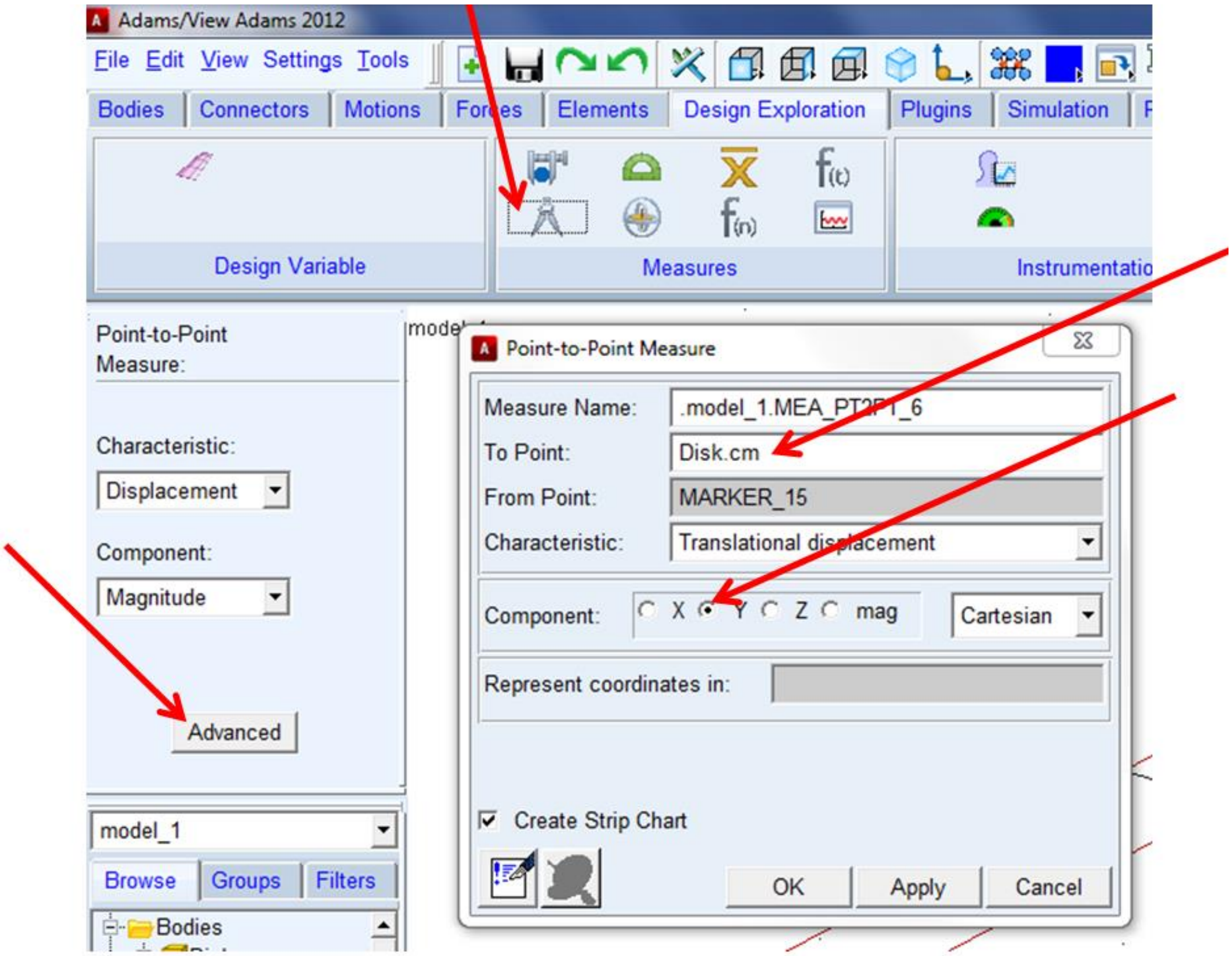


17- Modify the "Torque" to:

100000*(STEP(time, 0.1, 0, 0.11, 1) - STEP(time, 0.11, 0, 0.12, 1))

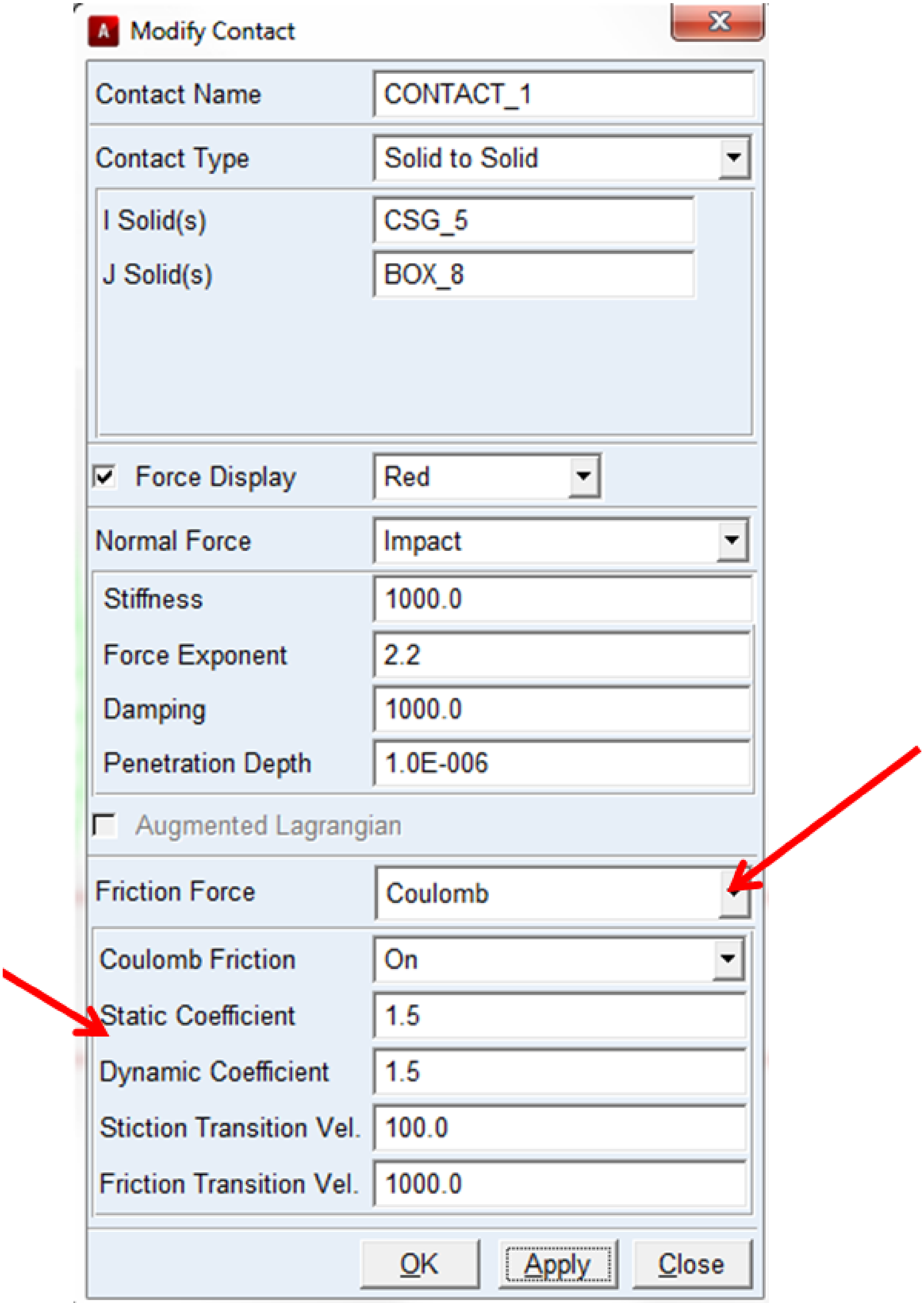


18- Create a Marker, add to ground at (0,0,0) then create a displacement probe that measures the distance in Y direction from the Disk.cm to the Marker (0,0,0). Recall from the last class, how to create a displacement probe:

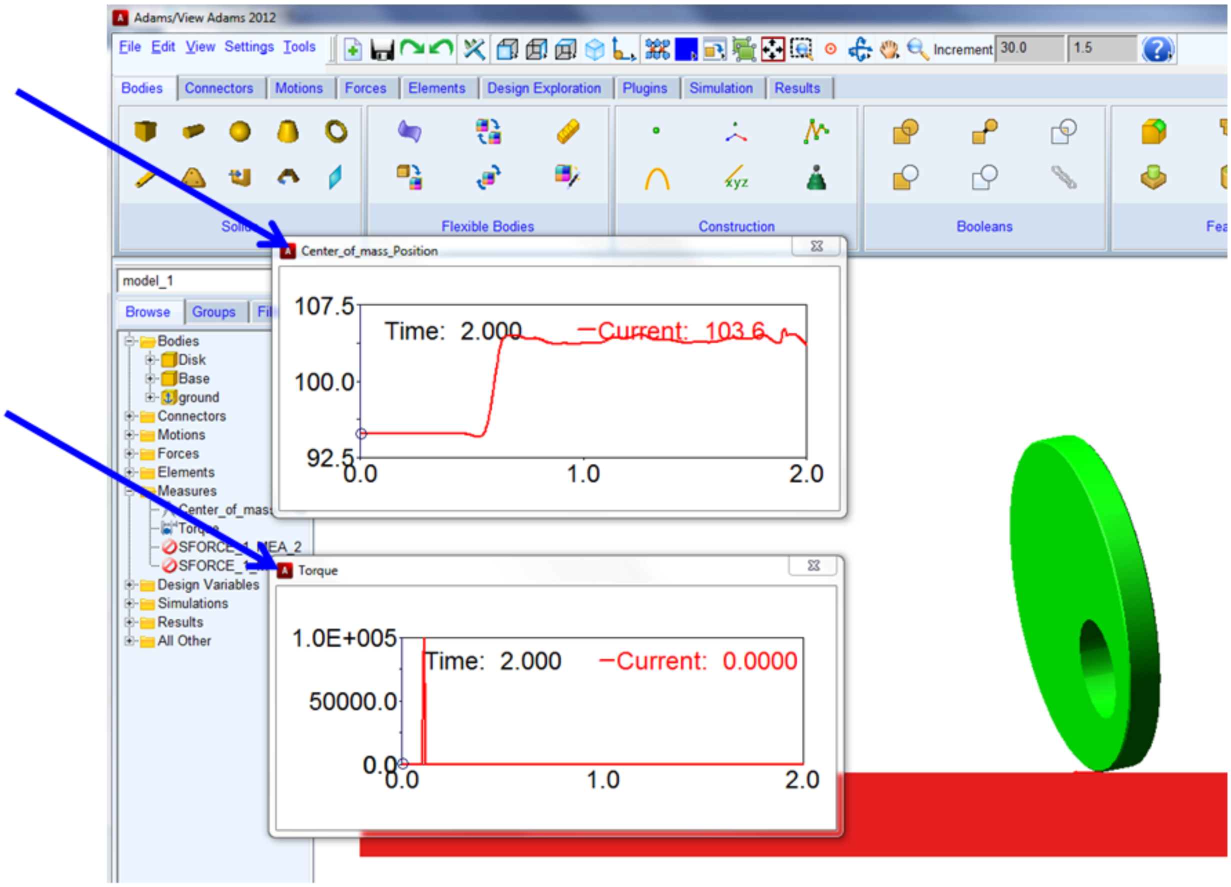


19- Run a simulation (2 sec. 1000) (Don't forget to tick "Start from Equilibrium")

20- Now add friction to the "Contact" by Modifying it and then select "Coulomb"; you should start with the following parameters, then change friction latter and observe different behaviour.


Modify Contact
Contact Name
CONTACT_1
Contact Type
Solid to Solid
I Solid(s)
CSG_5
J Solid(s)
BOX_8
Force Display
Red
Normal Force
Impact
Stiffness
1000.0
Force Exponent
2.2
Damping
1000.0
Penetration Depth
1.0E-006
Augmented Lagrangian
Friction Force
Coulomb
Coulomb Friction
On
Static Coefficient
1.5
Dynamic Coefficient
1.5
Stiction Transition Vel.
100.0
Friction Transition Vel.
1000.0
OK
Apply
Close

21- Run a simulation (2 sec. 1000) (Don't forget to tick "Start from Equilibrium")



Assignment:

Try to run different simulations. For example, examine:

- Different friction coefficients
- Different torque
- Change the density of the disk (i.e. very heavy disk)
- Change the contact parameters
- De-active "Gravity"; as if you are turning the disk in the air. (Does the center of mass flip?)
- Don't you think aerodynamics forces (due to the shape of the disk, with a hole in it) had some effect?
- Whatever you think is worth of trying!

Email a PDF file (a brief explanation of above investigations, graphs for each case) to ahmadpa20"gmail.com **before the start of your next ADAMS class.**

Chapter 6

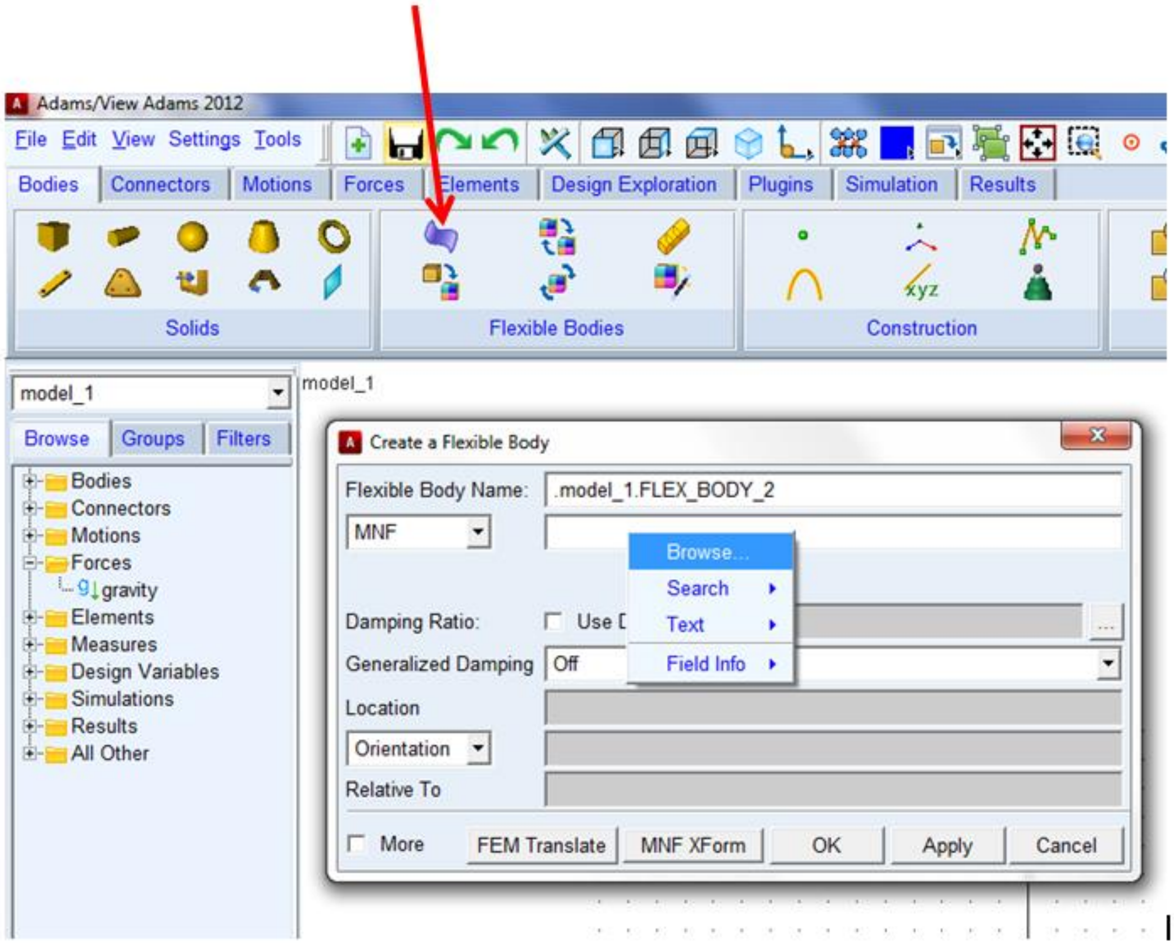
Diving Board (Flexible Beam)

Problem Description:

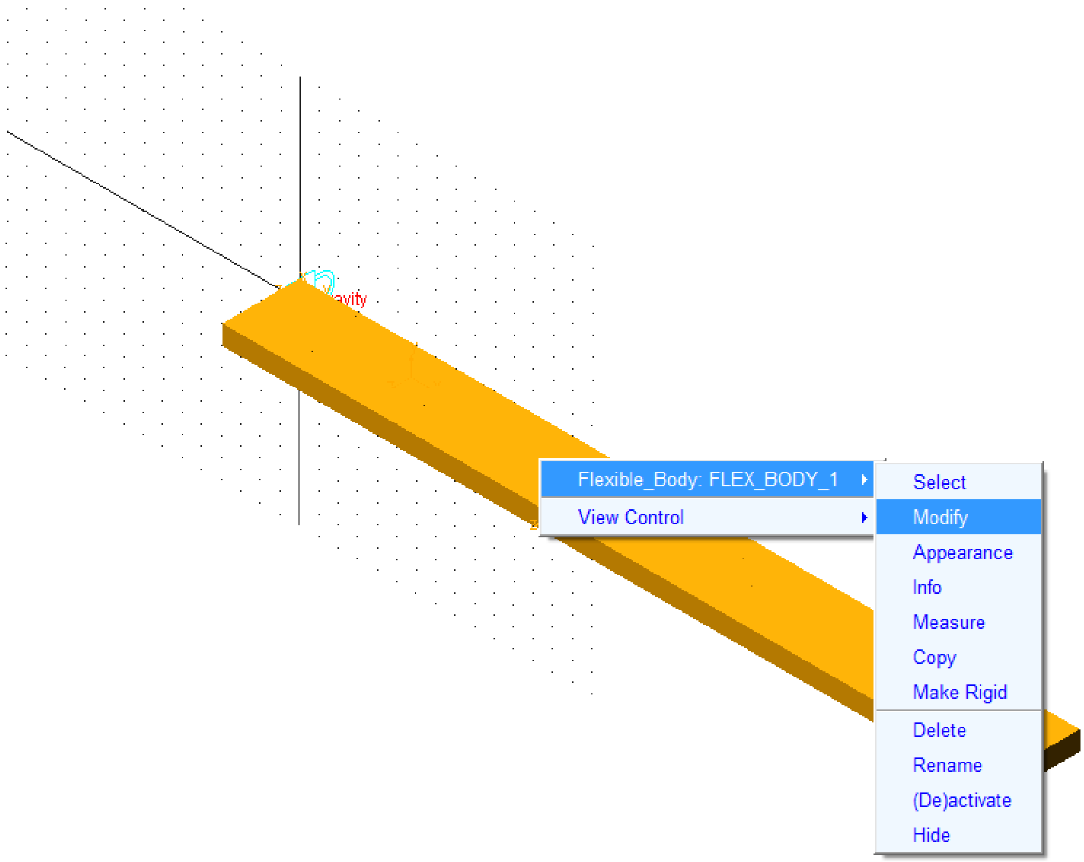
You will be modeling a diving board.

1- Put the **Beam.mnf** (The file is on the "CONNECT") in a New Folder that you are working on your model.

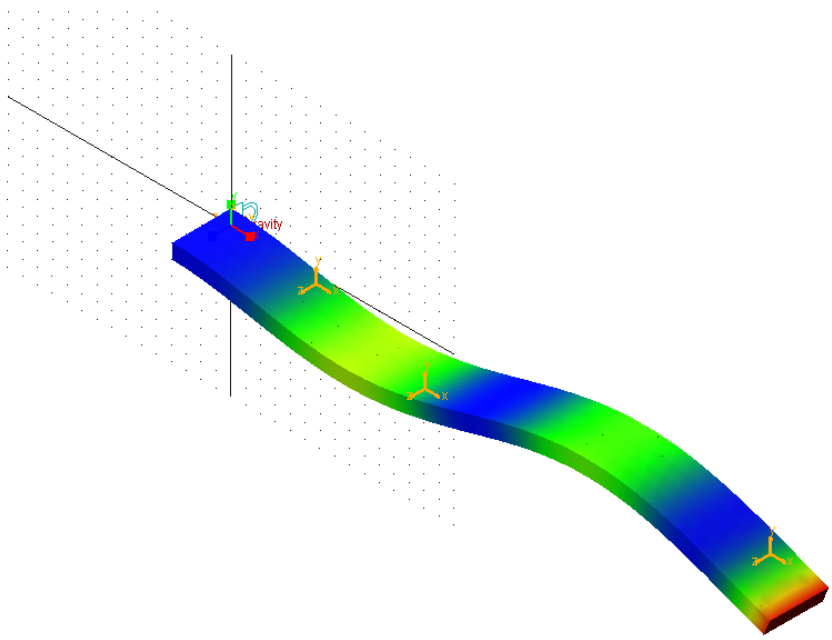
2- Browse the file by the "Creation of a Flexible Body" window: (don't forget to turn off the "Damping")

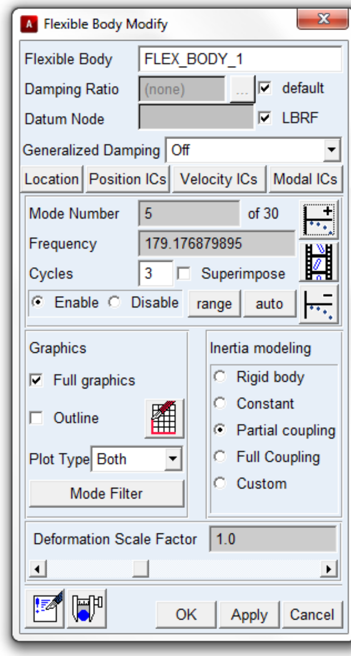


3- Right click on the beam, then Modify:



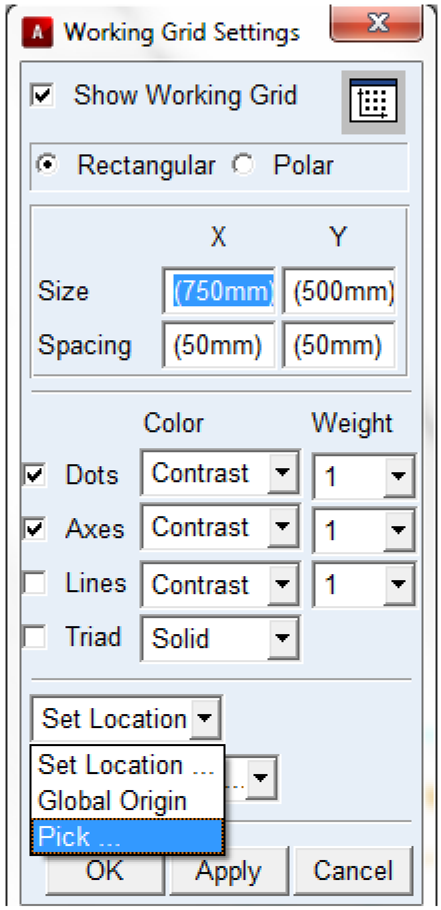
3- In following window, check the Frequencies and Mode Shapes of the Beam.





4- Create a Marker (add to ground) at (0,0, 100)

5- From setting “Working Grid” pick the Marker you just created as the location of the Center of the Grid.



Note that this is just the working grid, and it helps us for modeling; so changing that does not mean changing the global coordinate.

5- Create the following Markers at

(1000,80,100)

(800,80,100)

(850,500,100)

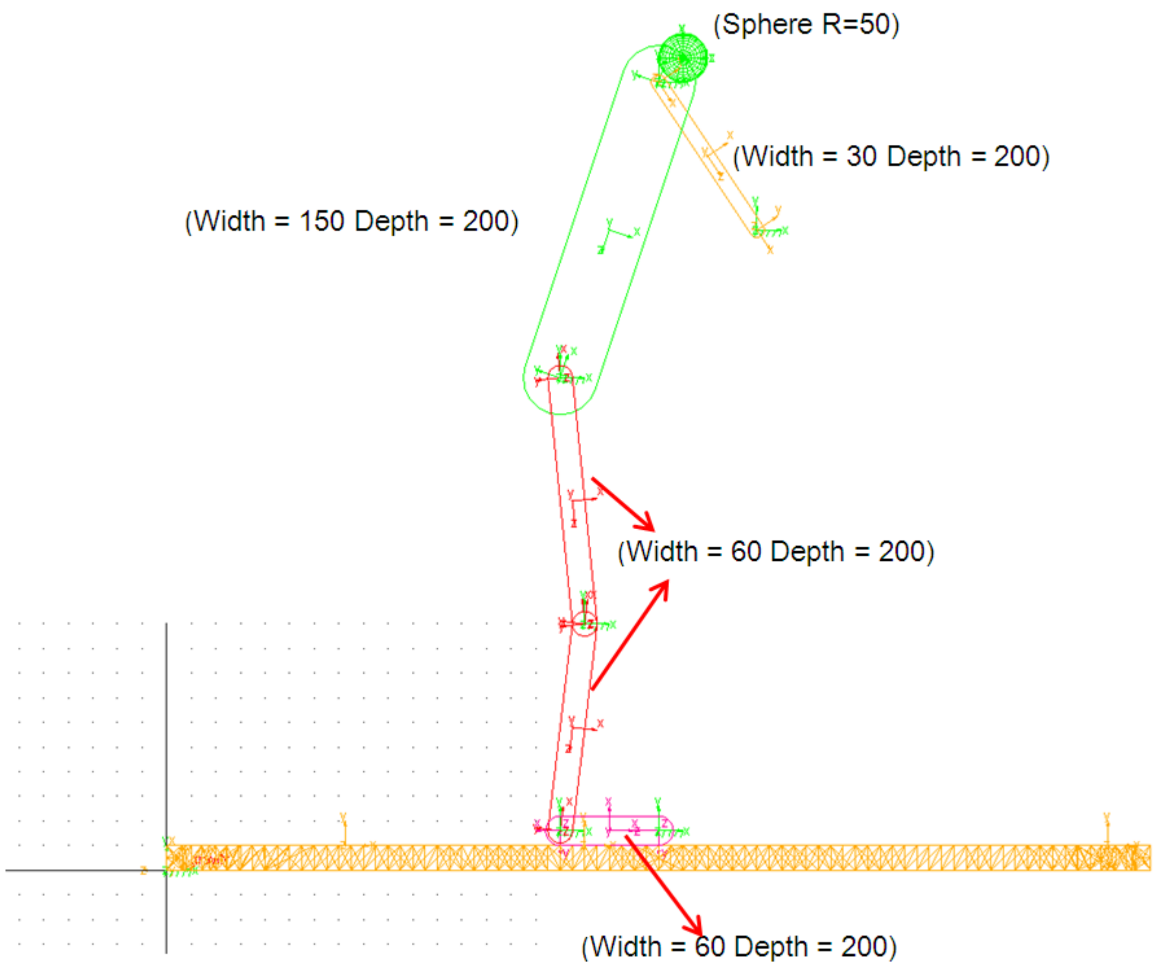
(800,1000,100)

(1000,1600,100)

(1050,1650,100)

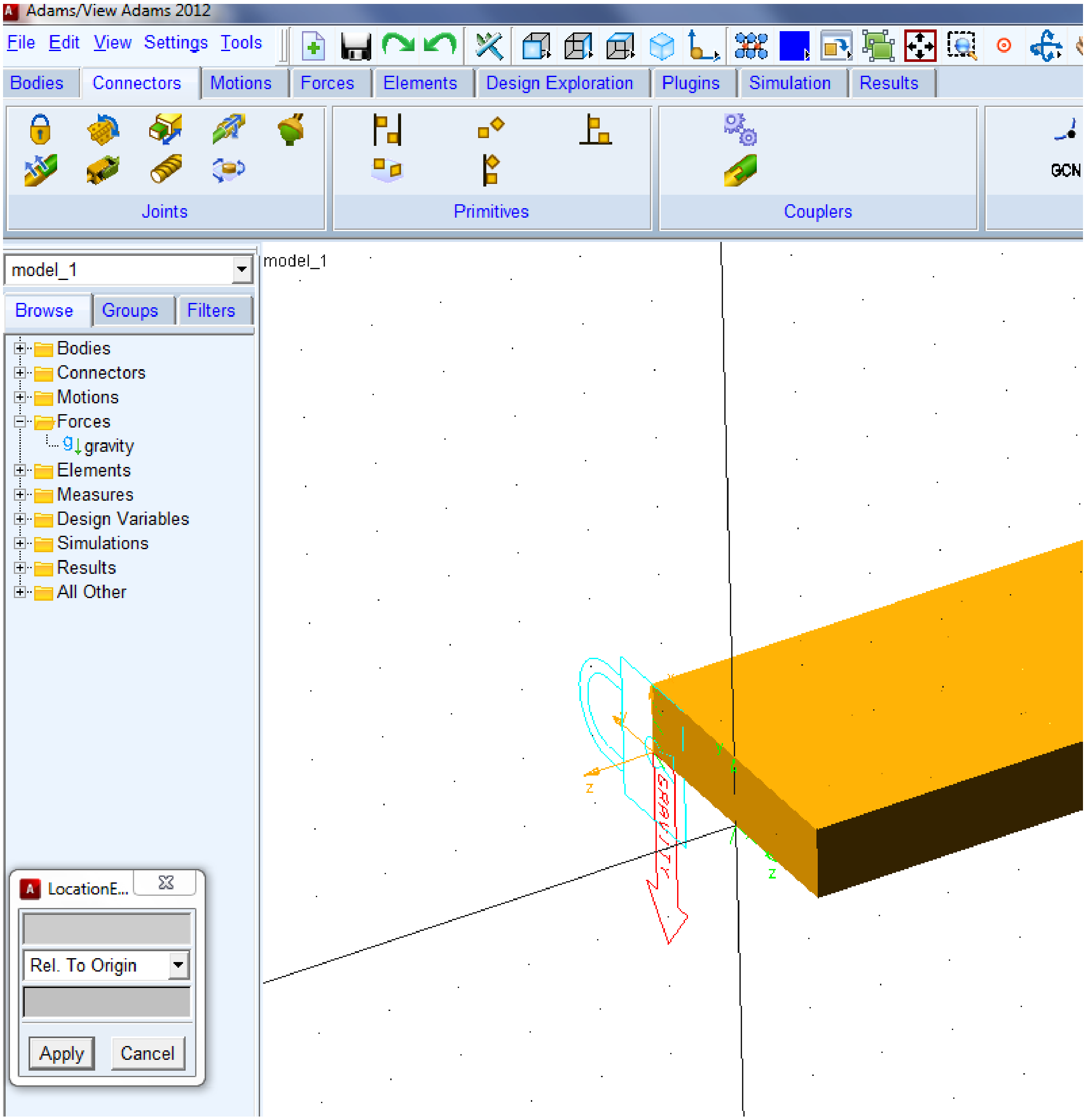
(1200,1300,100)

6- Use link, to create legs, hands, and body like these between the markers. Then Modify each "Link" as follow.

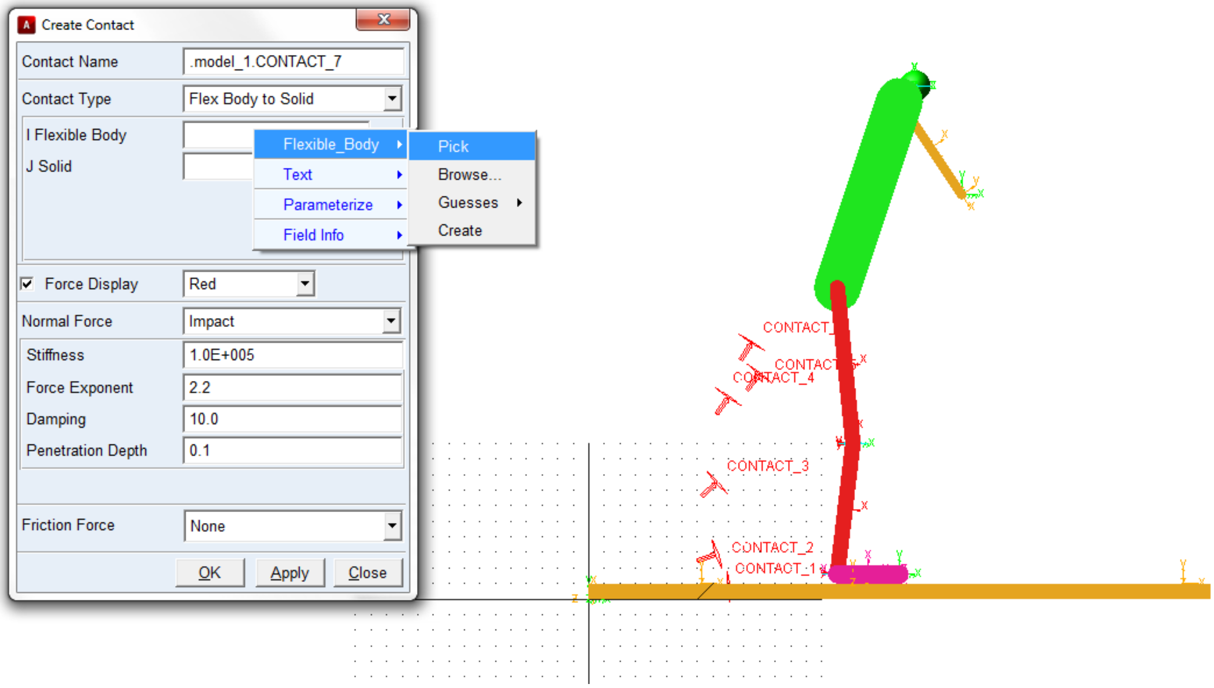


7- Create the joints in the body using "Revolute Joint"

8- Clamp the end of the beam (0,0,0) by "Fixed Joint"



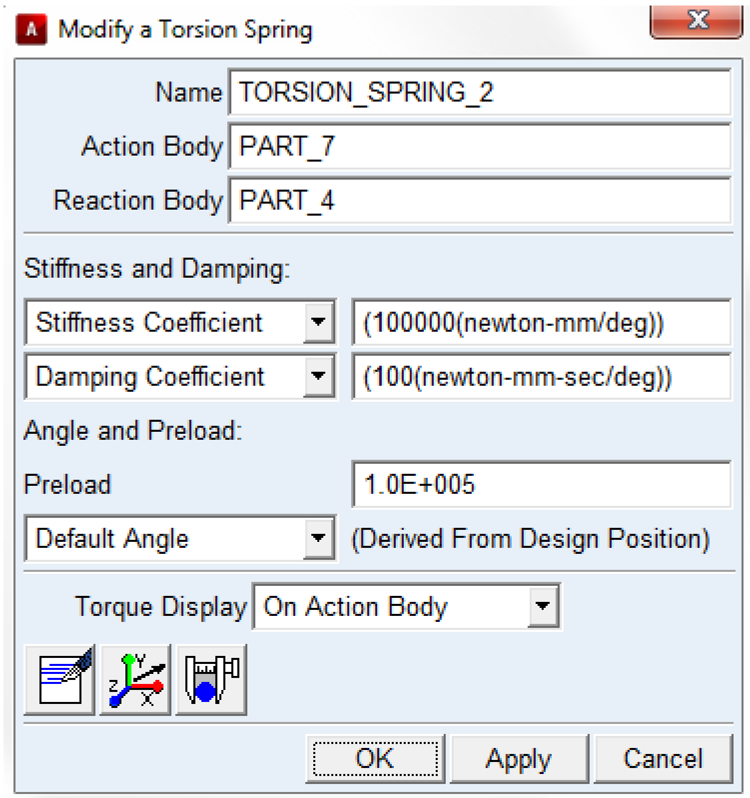
9- Create a contact between **all the parts** and the Beam. (Basically we need to create a contact between foot and the beam. But create contact between all parts and beam in this example). Put the numbers as the following window



10- Run a simulation!   1 sec 1000 steps 

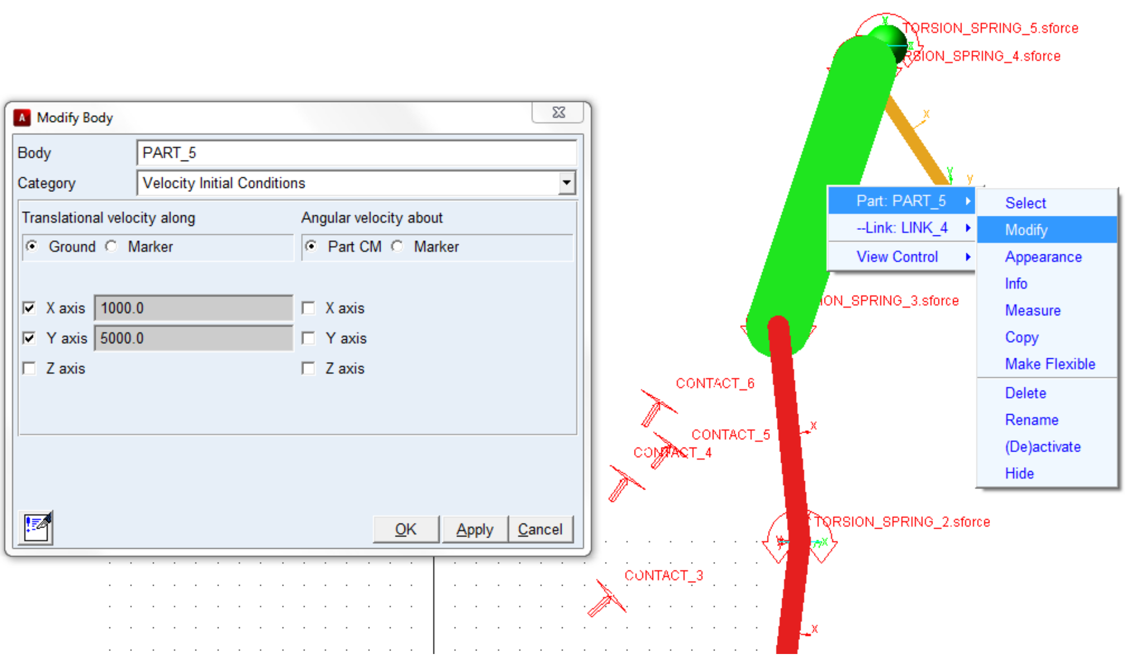
<u>So we need torsional spring for all joints!</u>

Torsional spring and damping and Pre load as follow for all the joint and for “hip”.



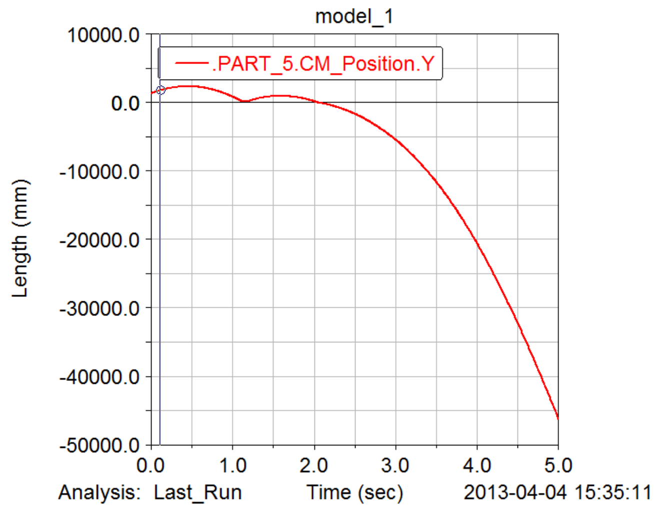
11- Run a simulation!   2 sec 1000 steps

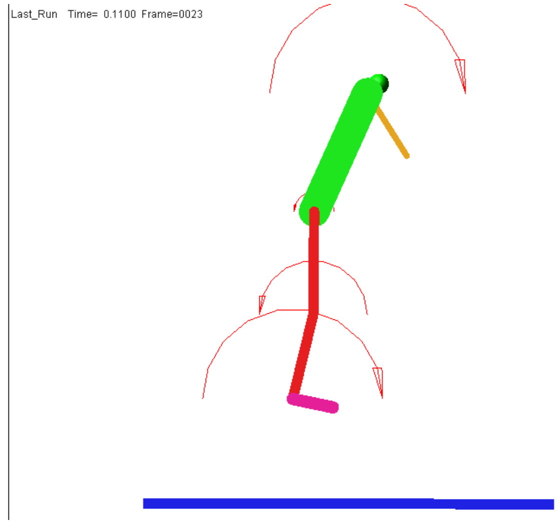
12- Change the initial velocity of the body (the stomach part) to:



13- 11- Run a simulation!   2 sec 1000 steps

14- Change the initial velocity of your "virtual Dummy" jumping so he can eventually do a successful diving.

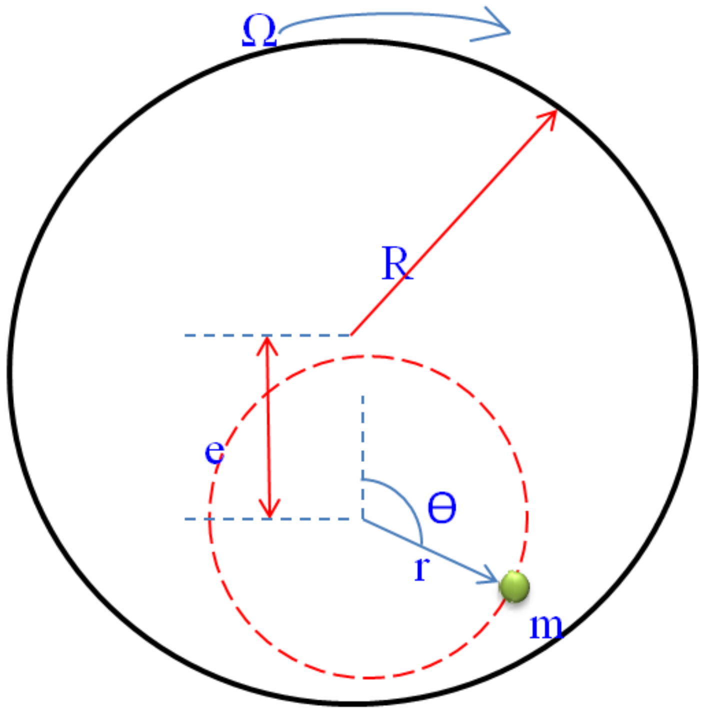


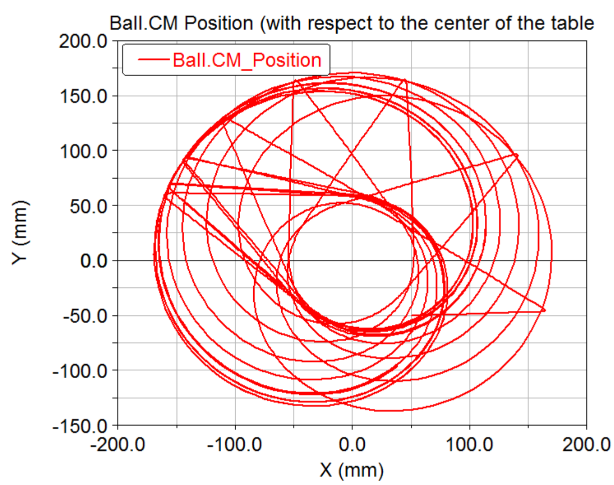


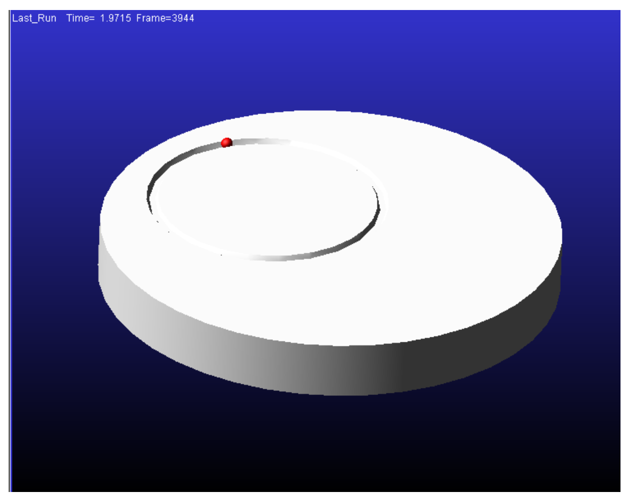
15- Try to measure different angles (between parts).

Assignment:

Investigate the dynamics characteristics of a small ball moving in the eccentric circular slot on a turning table.







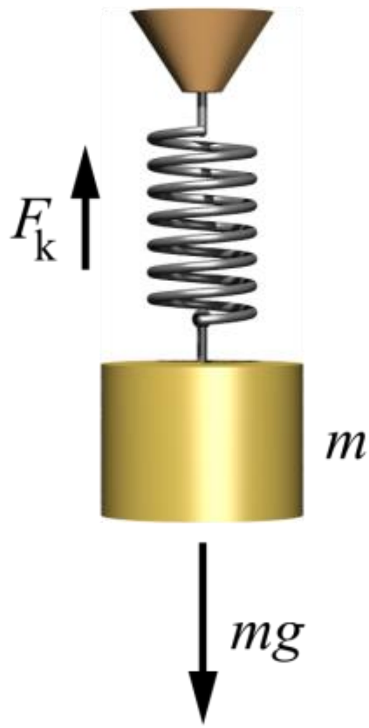
Email a PDF file (a brief explanation of your analysis, a graph that shows the position of the ball with respect to the center of the table) to ahmadpa20"gmail.com **before the start of your next ADAMS class.**

Chapter 7

Non-Linear Spring

Problem Description:

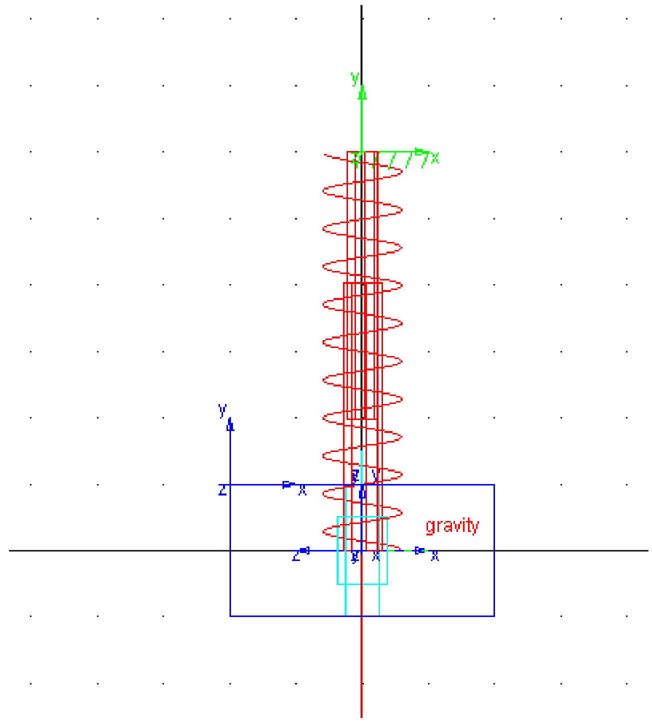
Model the following mass spring system.



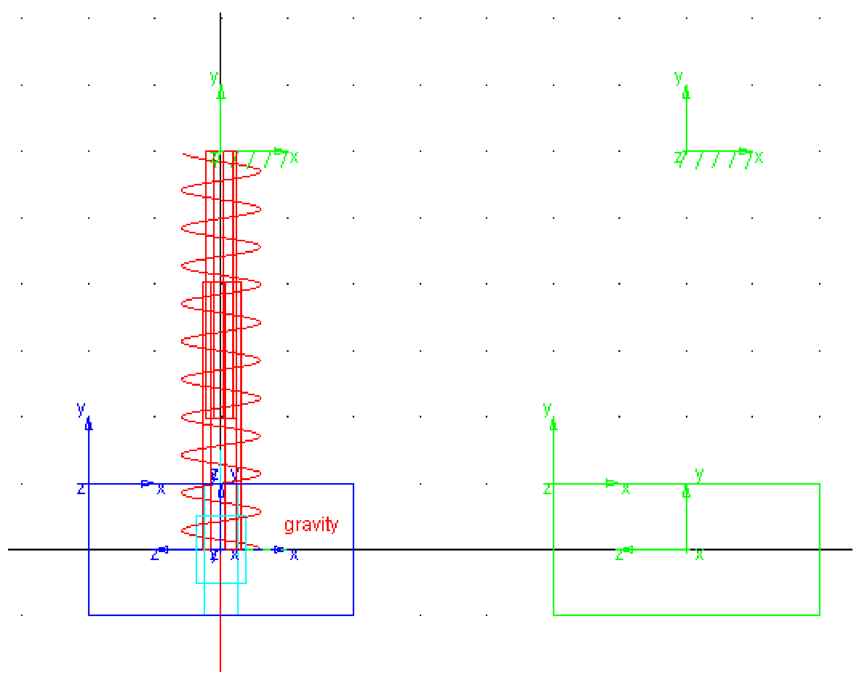
$$F_k = Kx + Kx^{1/3}$$

Conduct all the simulations that you have done for the system in Chapter one.

Step1. Create the similar model as the model in Chapter 1 with M=10Kg, K=1N/mm, C=0.

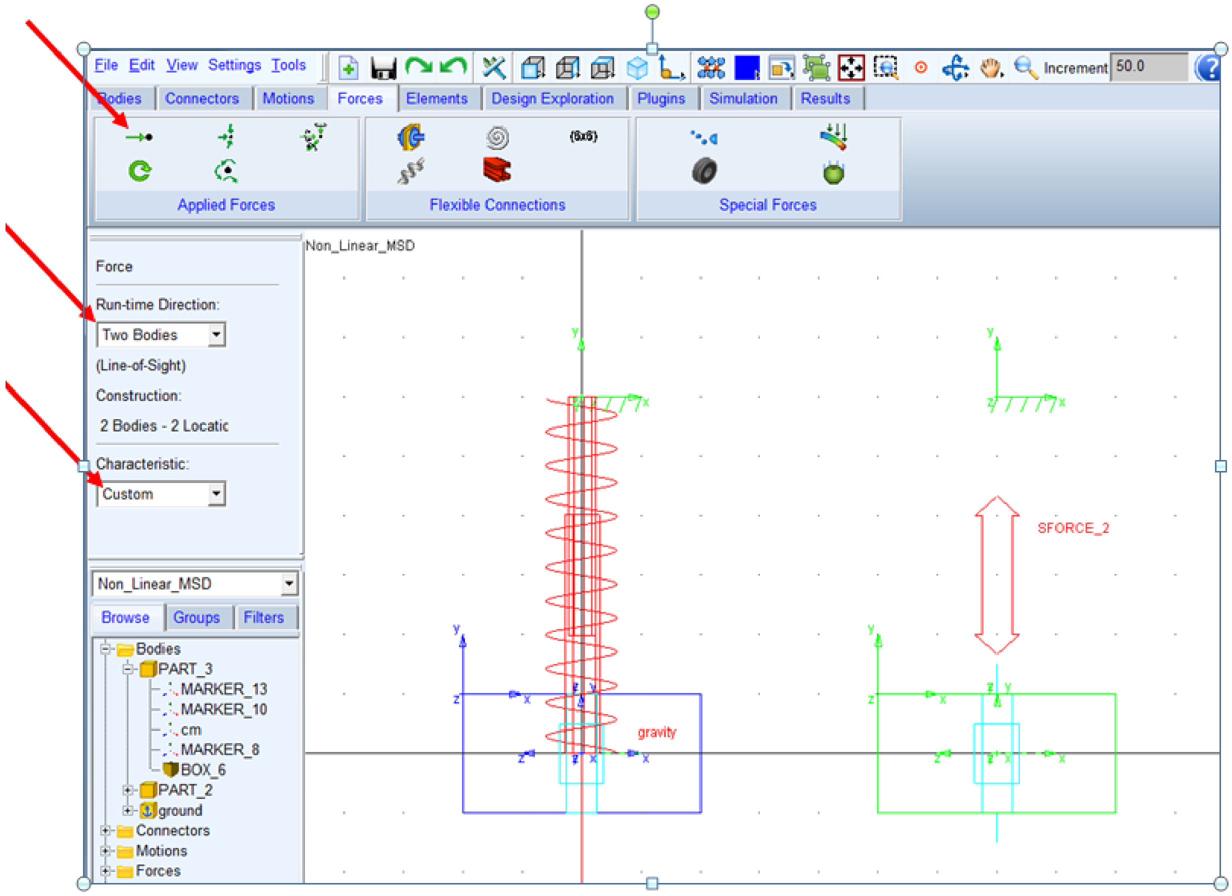


Step2. Create a box with the same geometry and mass beside the mass-spring system you have just created. (Modify the position, so the center of the new mass be at X=400 and Y=Z=0)



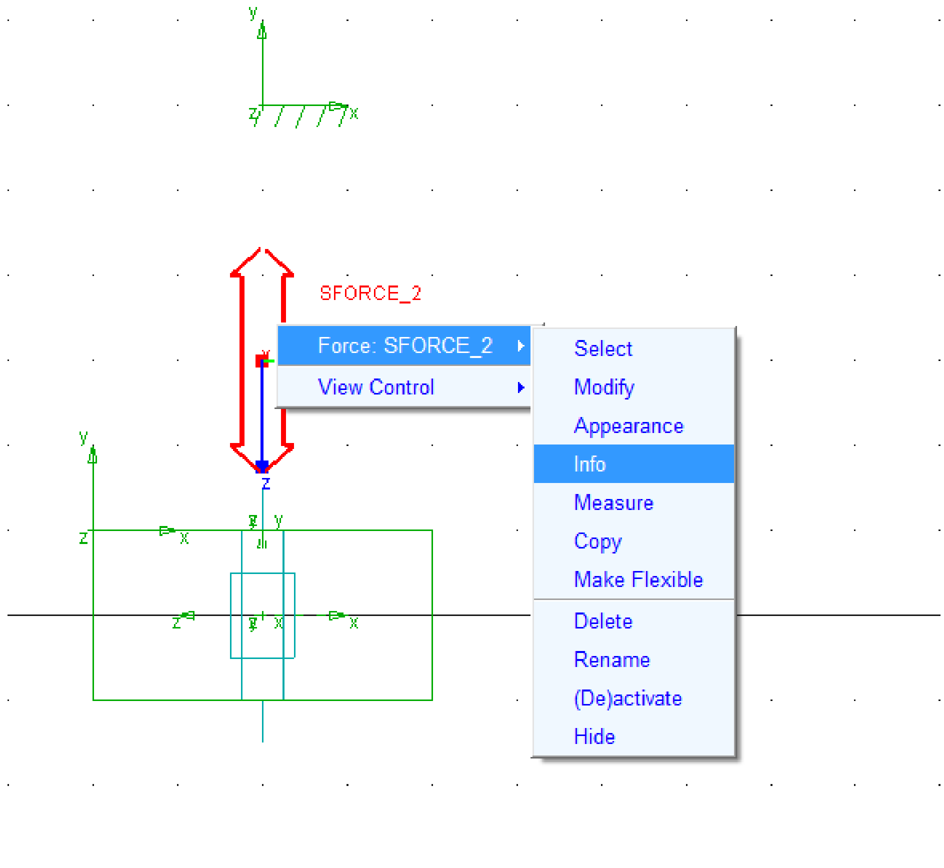
Step3. Create a marker at (400, 300, 0).

Step4. Create a custom force as following:

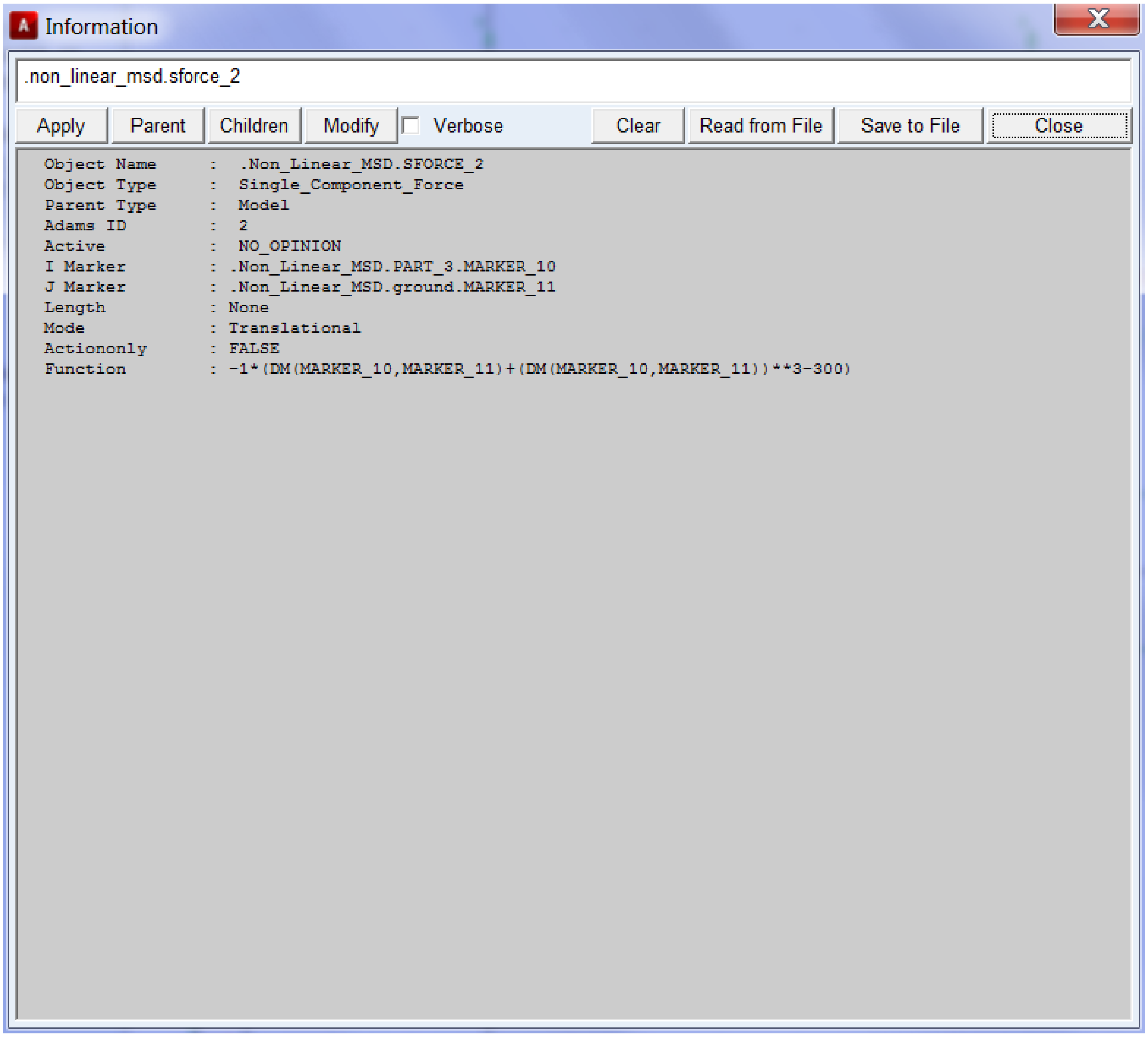


Leave the Window for the force for now; and follow the next steps.

Step 5. Right click on the Force you have just created and take “info”:



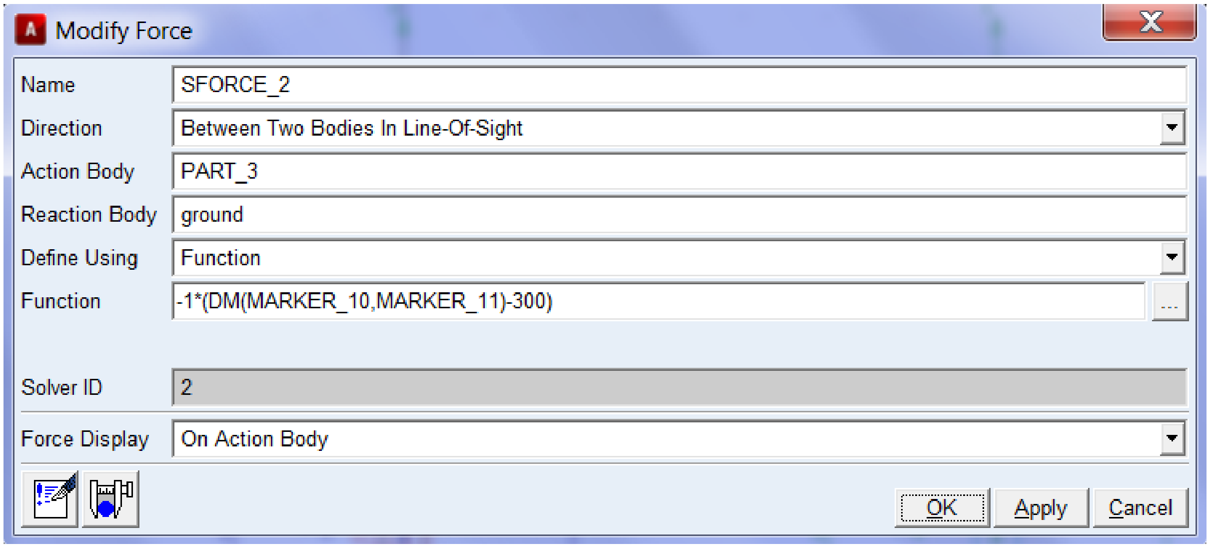
The following window should appear:



Remember the "I Marker and J Marker number". (Note that the I and J marker may be different numbers in your model)

Step 5. Modify the function for *F=Kx* in the window for the force: (Based on the I Marker and J Marker of your model) k=1 N/mm

-1*(DM(MARKER_10,MARKER_11)-300)



Step6. Run a simulation for 5 Sec. 500 Steps.

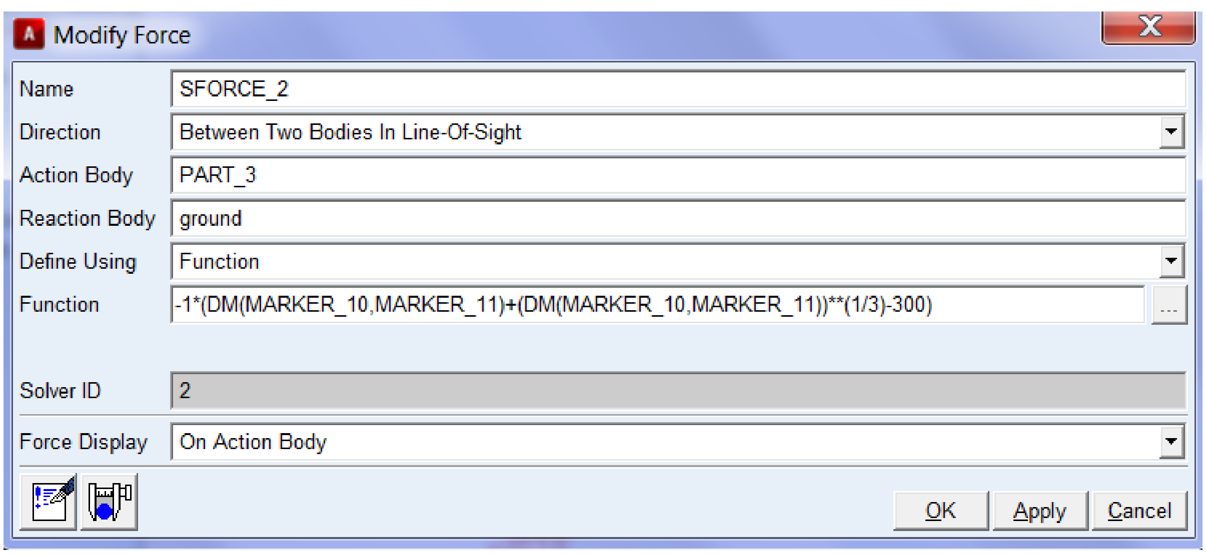
Step7. Check the displacement of the 2 box. They should be the same.

Now, you are sure that the function you have created for the force is correct.

Step 8. Change the function for:

$$F_k = Kx + Kx^{1/3}$$

-1*(DM(MARKER_10,MARKER_11)+(DM(MARKER_10,MARKER_11))**(1/3)-300)



Step9. Run a simulation (5 Sec) and compare the results with the linear spring.