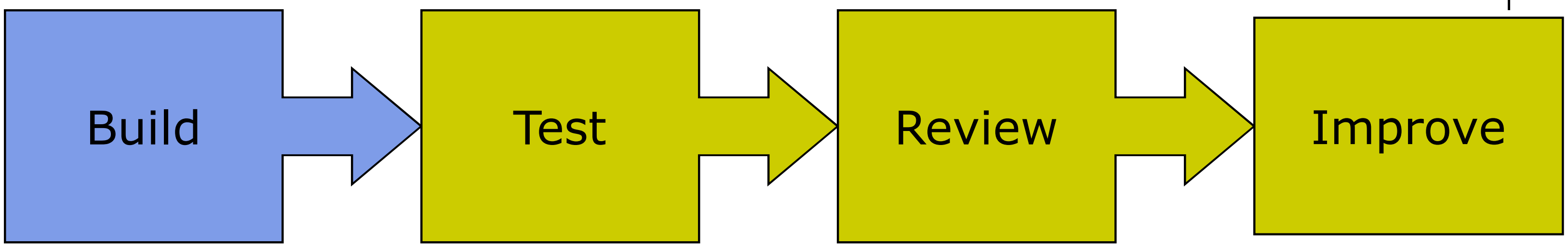
Introduction to ADAMS/View

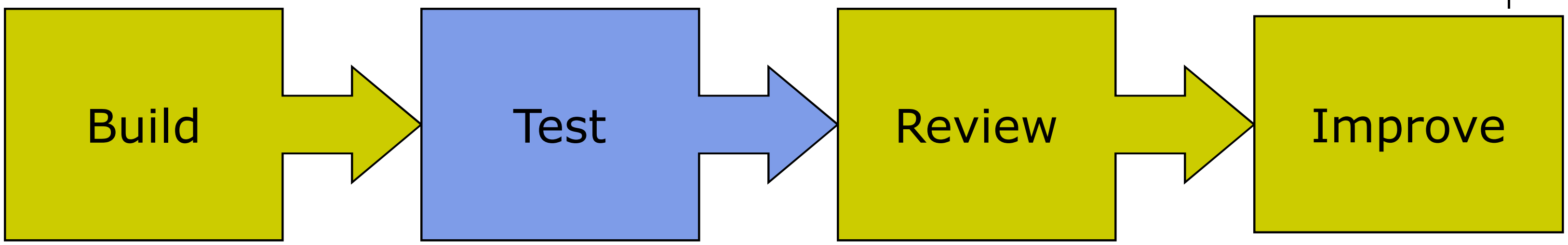
ME 451

VIRTUAL PROTOTYPING PROCESS



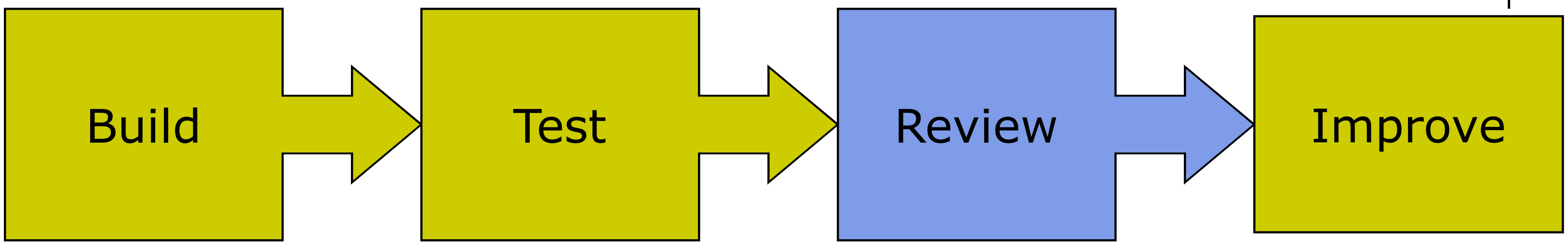
- Build a model of your design using:
  - Bodies
  - Forces
  - Contacts
  - Joints
  - Motion generators

VIRTUAL PROTOTYPING PROCESS



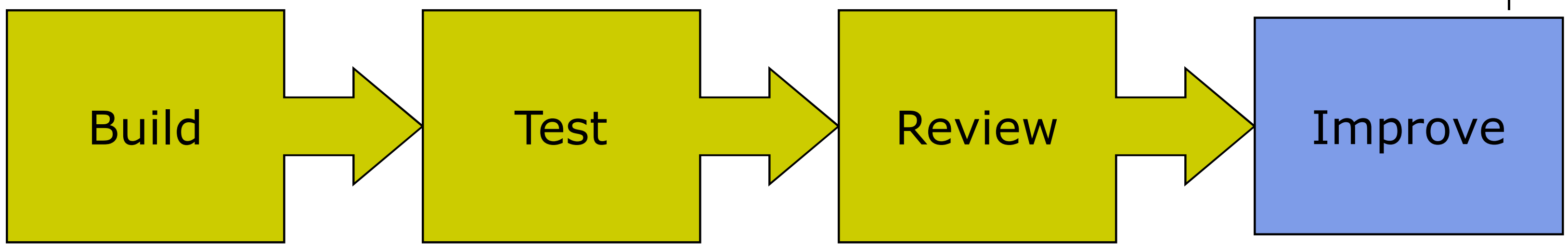
- Test your design using:
  - Measures
  - Simulations
  - Animations
  - Plots
- Validate your model by:
  - Importing test data
  - Superimposing test data

VIRTUAL PROTOTYPING PROCESS



- Review your model by adding:
  - Friction
  - Forcing functions
  - Flexible parts
  - Control systems
- Iterate your design through variations using:
  - Parametrics
  - Design Variables

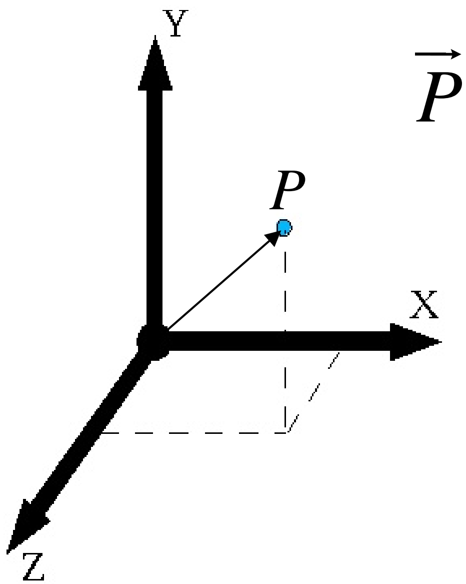
VIRTUAL PROTOTYPING PROCESS



- Improve your design using:
  - DOEs
  - Optimization
- Automate your design process using:
  - Custom menus
  - Macros
  - Custom dialog boxes

Coordinate Systems

- Definition of a coordinate system (CS)
  - A coordinate system is essentially a measuring stick to define kinematic and dynamic quantities.



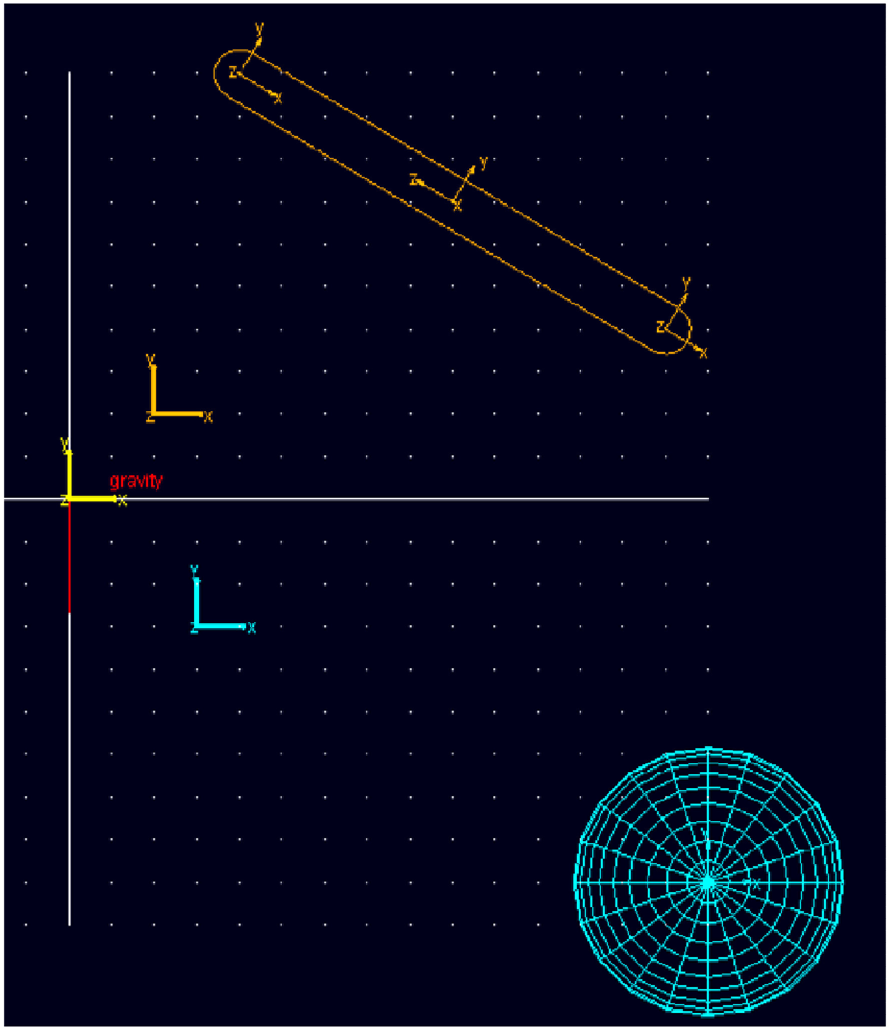
$$\vec{P} = P_x \hat{x} + P_y \hat{y} + P_z \hat{z}$$

Coordinate Systems

- Types of coordinate systems
  - Global coordinate system (GCS):
    - Rigidly attaches to the ground part.
    - Defines the absolute point (0,0,0) of your model and provides a set of axes that is referenced when creating local coordinate systems.
  - Local coordinate systems (LCS):
    - Part coordinate systems (PCS)
    - Markers

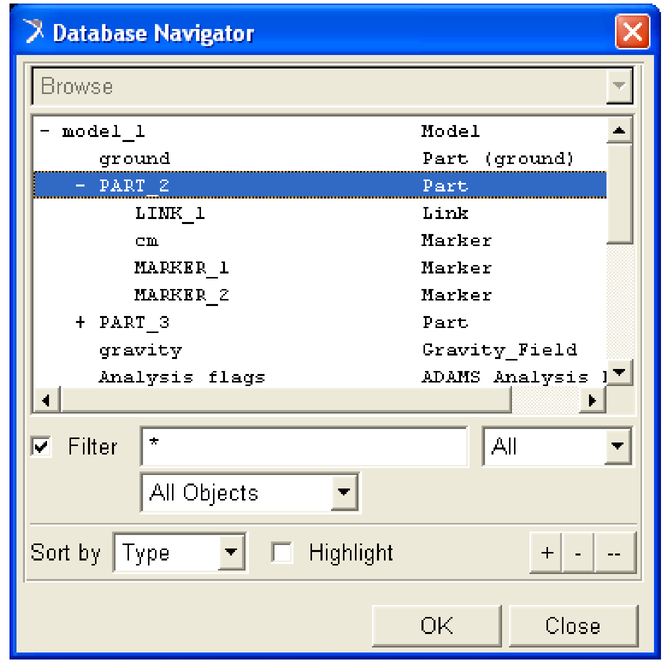
Part Coordinate Systems

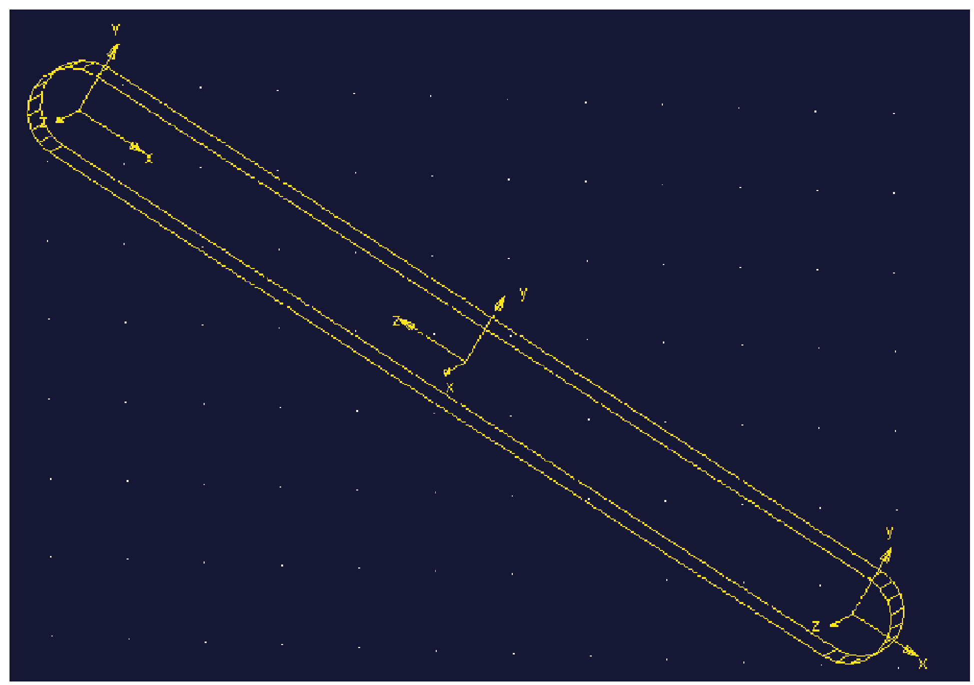
- Definition of part coordinate systems (PCS)
  - They are created automatically for every part.
  - Only one exists per part.
  - Location and orientation is specified by providing its location and orientation with respect to the GCS.
  - When created, each part's PCS has the same location and orientation as the GCS.



Markers

- Definition of a marker
  - It attaches to a part and moves with the part.
  - Several can exist per part.
  - Its location and orientation can be specified by providing its location and orientation with respect to GCS or PCS.





Markers

- Definition of a marker (cont.)
  - It is used wherever a **unique location** needs to be defined. For example:
    - The location of a part’s center of mass.
    - The reference point for defining where graphical entities are anchored.
  - It is used wherever a **unique direction** needs to be defined. For example:
    - The axes about which part mass moments of inertia are specified.
    - Directions for constraints.
    - Directions for force application.
  - By default, in ADAMS/View, all marker locations and orientations are expressed in GCS.

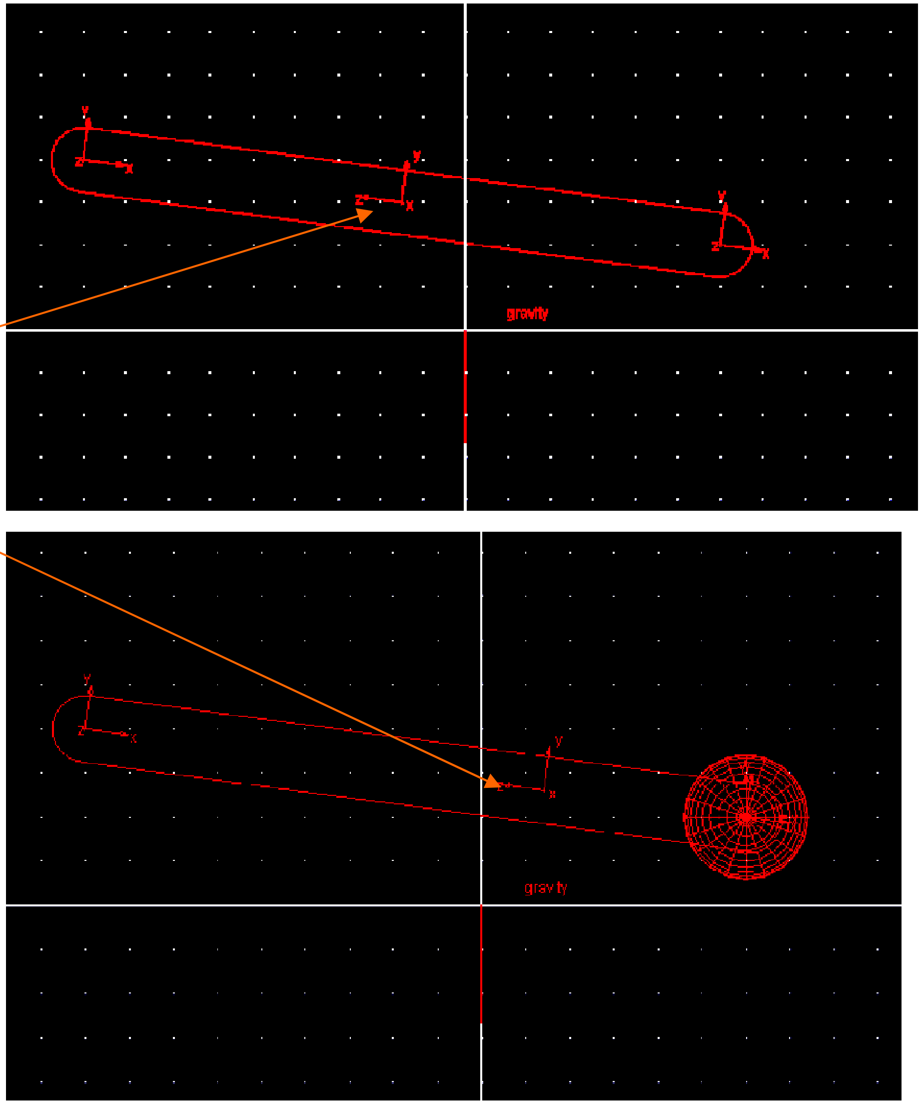
Difference between part and geometry

- Parts
  - Define bodies (rigid or flexible) that can move relative to other bodies and have the following properties:
    - Mass
    - Inertia
    - Initial location and orientation (PCS)
    - Initial velocities
- Geometry
  - Is used to add graphics to enhance the visualization of a part using properties such as:
    - Length
    - Radius
    - Width
  - Is not necessary for most simulations.

  - Simulations that involve contacts do require the part geometry to define when the contact force.

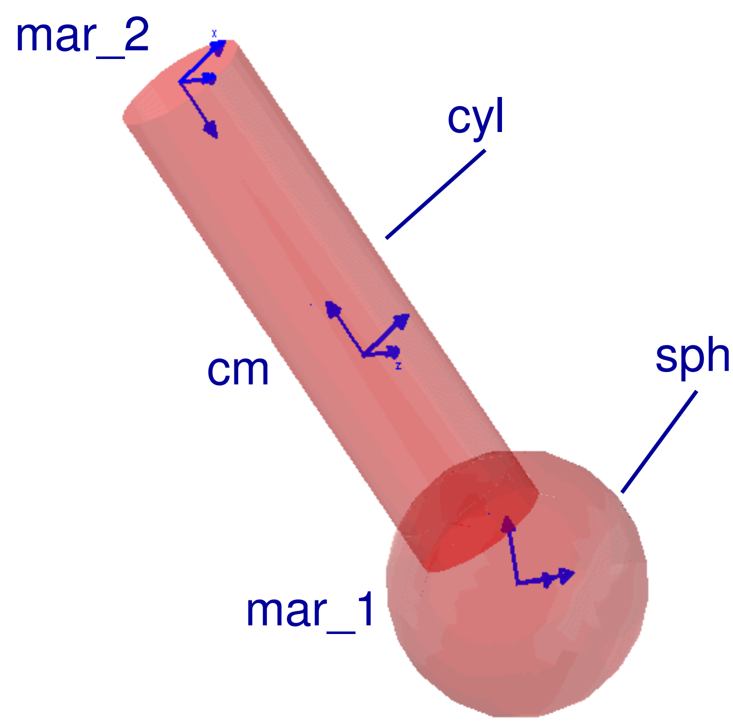
Difference between part and geometry

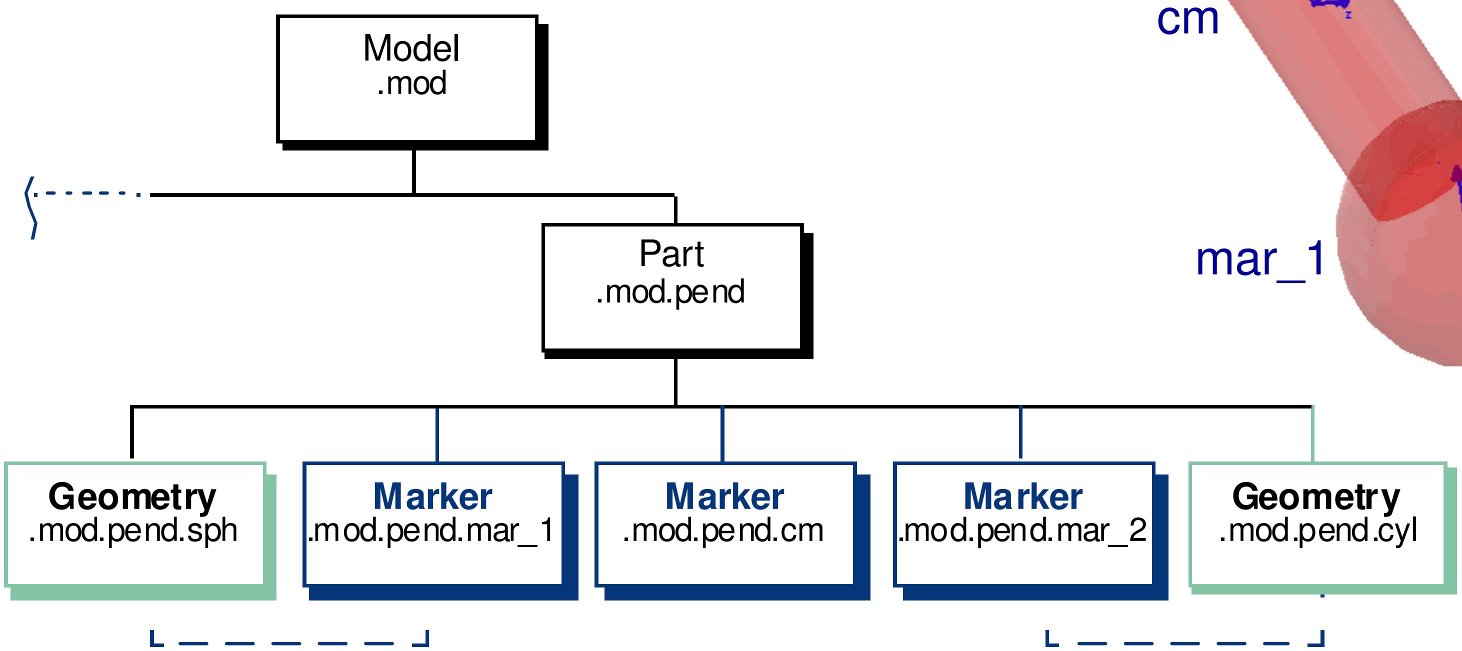
Center of Mass
Marker



Difference between part and geometry

- Dependencies in ADAMS/View





Creating some parts

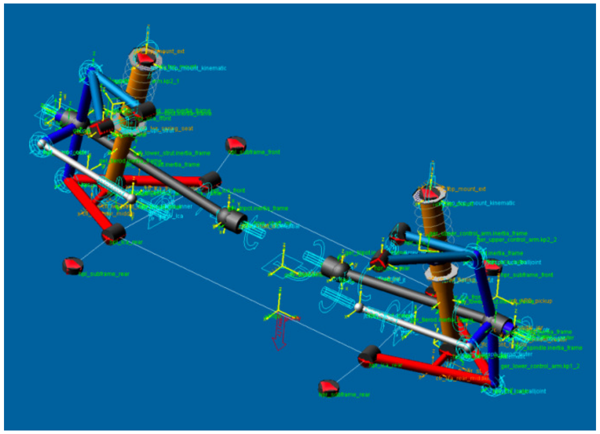
- Link
- Box
- Sphere
- Extrusion
- Importing a geometry from CAD package…. Parasolid…

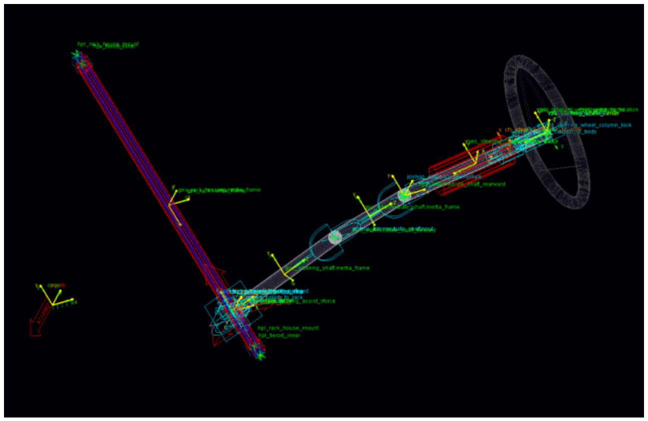
Constraints

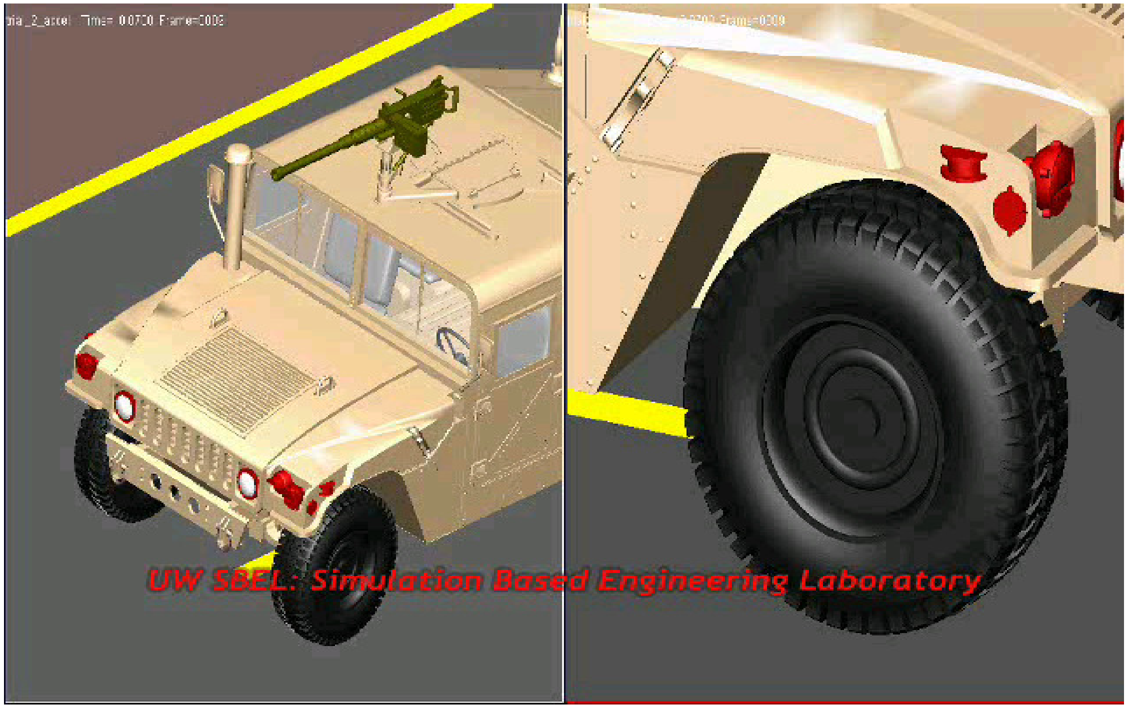
- Definition of a constraint
  - Restricts relative movement between parts.
  - Represents idealized connections.
  - Removes rotational and/or translational DOF from a system.
- Joints
  - Revolute
  - Translational
  - Fixed
  - Other…… ______________________________

HMMWV Vehicle Model

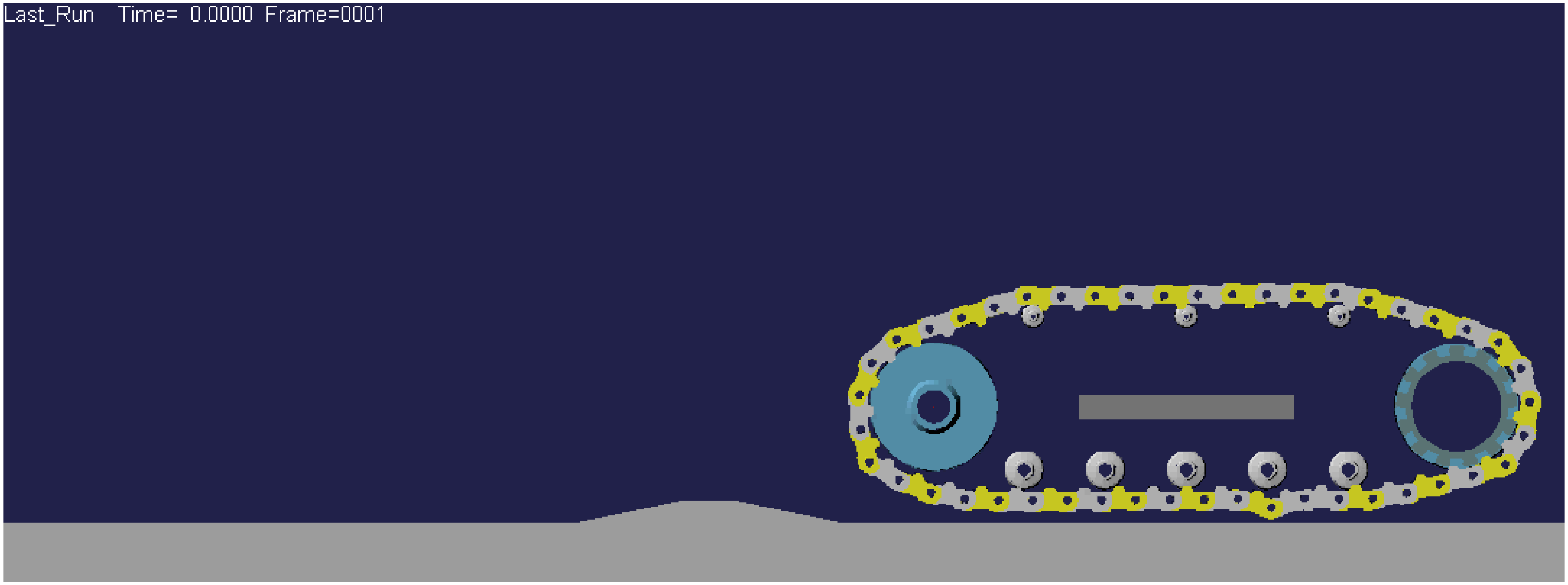
- High Mobility Multipurpose Wheeled Vehicle (HMMWV) modeled in ADAMS/Car







Track Model



Let's create some mechanisms

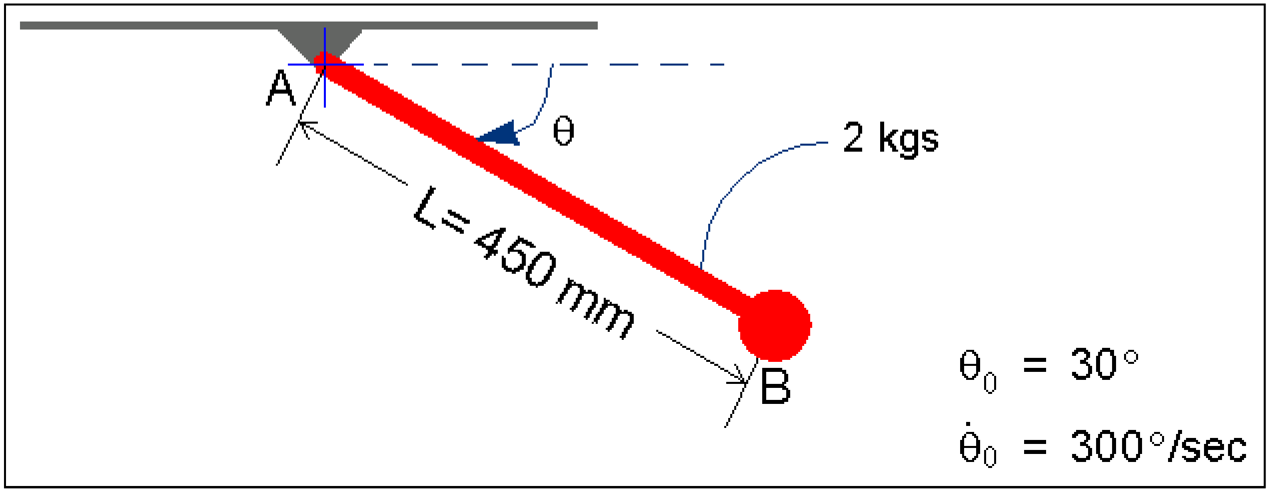
- Simple pendulum
  - Single body – mass attached with a wire
    - wireis massless
  - Two body – mass attached to a link
    - Link has mass
- Slider crank
  - Transfers power from piston-cylinder to shaft in a car engine
  - Transfers power in opposite direction when used as an air compressor

Applications

- Application of this virtual prototyping
  - One can review forces coming on joints, and hence select appropriate bearings
  - Torques acting at the joints can be found and hence an appropriate motor can be selected based on the operating speed and torque requirements
  - A controls module can be added and tested
  - All mass properties, geometries, operating speeds etc can be changed and their effects can be evaluated

WORKSHOP ONE DOF PENDULUM

- Problem statement
  - Find the initial force supported by the pin at A for a bar that swings in a vertical plane, given the initial angular displacement (θ_0) and initial angular velocity ($\dot{\theta}_0$). Also, find the pendulum frequency.



WORKSHOP – ONE DOF PENDULUM

- Start the workshop
  - First, you'll start ADAMS/View from a directory you can write files to
  - Last time I checked, ADAMS/View is in Course Software→Supported→MD Adams View
- To start ADAMS/View and create a model:
  - Start ADAMS/View:
    - Set the directory to anywhere on one of your CAE hard drives
    - Create a new model named **pendulum**, with **Gravity** set to **Earth Normal (-Global Y)**, and **Units** set to **MMKS - mm, Kg, N, s, deg**.

WORKSHOP – ONE DOF PENDULUM

- Build the pendulum link

  Now, build the link section of the pendulum using the following parameters:

  - Width: 20 mm
  - Depth: 27.5mm
  - Endpoints: (0, 0, 0) and (450, 0, 0)

WORKSHOP – ONE DOF PENDULUM

- To build the link:
  1. Turn on the coordinate window.
  2. From the Main Toolbox, right-click the **Rigid Body** tool stack, and then select the **Link** tool  .
  3. In the container:
     - Select **New Part**.
     - Select **Length**, and in the **Length** text box, enter **450 mm**, and then press **Enter**.
     - Select **Width**, and in the **Width** text box, enter **20 mm**, and then press **Enter**.
     - Select **Depth**, and in the **Depth** text box, enter **27.5 mm**, and then press **Enter**.
  4. Using the mouse, select **0, 0, 0** and **450,0,0** as the endpoint locations.
  - ***Tip:*** Use the Location Event (right-click away from the model) to help select the endpoints. When you right-click, the Location Event appears in the lower left corner of the ADAMS/View window. Enter the coordinates for the link in the upper text box and then press **Enter**.

WORKSHOP – ONE DOF PENDULUM

- Build the sphere section

  Next, build the sphere section of the pendulum using the following parameters:

  - Add to Part
  - Radius: 25 mm
  - Centerpoint: 450, 0, 0

WORKSHOP – ONE DOF PENDULUM

- To build the sphere section:
  1. From the Main Toolbox, right-click the **Rigid Body** tool stack, and then select the **Sphere** tool .
  2. In the container:
     - Select **Add to part**.
     - Select **Radius**, and in the **Radius** text box, enter **25 mm**, and then press **Enter**.
  3. Using the mouse, select **PART_2**, which is the link, as the part to add to.
  4. Using the mouse, select **450,0,0** as the location.

WORKSHOP – ONE DOF PENDULUM

- Rename the pendulum

  Now you'll rename the pendulum from PART_2 to Pendulum.

- To rename the pendulum:

  1. Right-click the **link**, point to **Part:PART_2**, and then select **Rename**.

     The Rename Object dialog box appears.

  2. In the **New Name** text box, enter **.pendulum.pendulum**, and then select **OK**.

WORKSHOP – ONE DOF PENDULUM

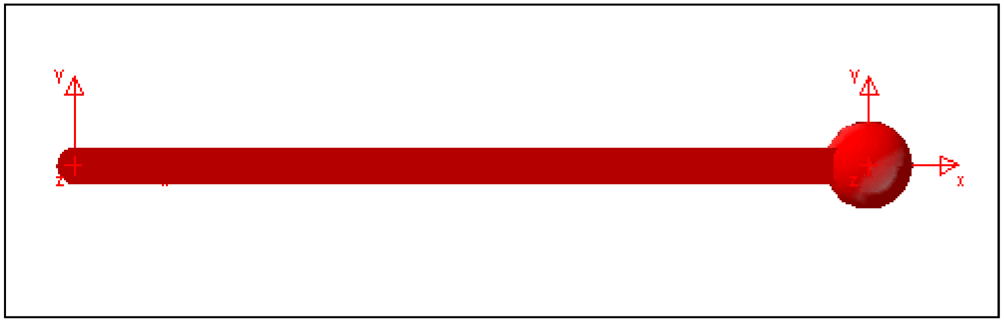
- Set the mass of the pendulum
  - Now, set the mass of the pendulum to 2 kg, set all three inertias (I_{xx}, I_{yy}, I_{zz}) to 0, and change the location of the center of mass.
- To set the mass of the pendulum:
  1. Right-click the **pendulum**, point to **Part: pendulum**, and then select **Modify**.
  2. Set **Define Mass by** to **User Input**.
  3. In the **Mass** text box, enter **2.0**.
  4. In the **Inertia** text boxes (I_{xx}, I_{yy}, I_{zz}), enter **0**.
  5. Right-click the **Center of Mass Marker** text box, point to **pendulum.pendulum.cm**, and then select **Modify**.

WORKSHOP – ONE DOF PENDULUM

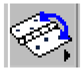
6. In the **Location** text box, enter **450, 0, 0**.
7. Select **OK** in both dialog boxes.

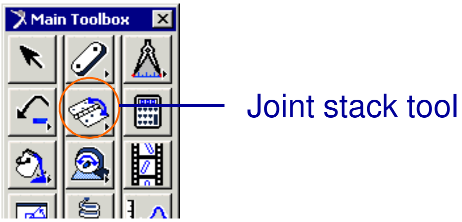
   You will receive a warning in the Message Window concerning the change in position of your center of mass marker.
8. Select **Close** to close the Message Window.

- Your model should look like this (with shading turned on):



WORKSHOP – ONE DOF PENDULUM

- Build the pivot
  - In this section, you'll build the pivot by creating a revolute joint between ground and the pendulum at location A, as shown in the figure in Workshop 6, slide 3, and rename it Pivot.
- To build the pivot:
  1. From the Main Toolbox, right-click the **Joint** tool stack, and then select the **Revolute joint** tool .



  2. In the container, select **2 Bod-1 Loc** and **Normal to Grid**.
  3. Select the **pendulum** as the **first body**.
  4. Select the **ground** as the **second body**.
  5. Select **0, 0, 0** as the **location**.

WORKSHOP – ONE DOF PENDULUM

- To rename the joint:
  1. Right-click the **revolute** joint, point to **Joint:JOINT_1**, and then select **Rename**.
  2. In the **New Name** text box, enter **.pendulum.pivot**, and then select **OK**.

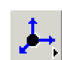
WORKSHOP – ONE DOF PENDULUM

- Create measures
  - Create two object (joint) measures to track the force supported by the pin, resolved in the x_g and $\hat{y}_g$ directions.
- To create object measures:
  1. Right-click the **pivot** joint, point to **Joint:pivot**, and then select **Measure**.
  2. In the dialog box:
     - In the **Measure Name** text box, enter **pivot_force_x**.
     - Set **Characteristic** to **Force,** and select **X** as the **Component**.
     - Be sure **.pendulum.MARKER_4** and **Create Strip Chart** are selected.
     - Select **Apply**.

     A stripchart displays the force during simulation and animation.
  3. In the dialog box:
     - In the **Measure Name** text box, enter **pivot_force_y**.
     - Set **Characteristic** to **Force**, select **Y** as the **Component**.
     - Be sure **.pendulum.MARKER_4** and **Create Strip Chart** are selected.
     - Select **OK**.

     A stripchart displays the force during simulation and animation.

WORKSHOP – ONE DOF PENDULUM

- Create a reference marker
  - Create a marker on ground to use as a reference location for the angle measure you will create in the next section. Instead of right-clicking on the marker to change its name, you'll use the **Edit** menu.
- To create a reference marker:
  1. On the Main Toolbox, right-click the **Rigid Body** tool stack, and then select the **Marker** tool  .
  2. In the container, be sure that **Add to Ground** and **Global XY** are selected.
  3. Using the mouse, select **450, 0, 0** as the location.
  4. With the marker still selected, from the **Edit** menu, select **Rename**.
  5. In the **New Name** text box, enter **.pendulum.ground.angle_ref**, and then select **OK**.

WORKSHOP – ONE DOF PENDULUM

- Create angle measure
  - Now, create the angle measure to track the angular displacement of the pendulum, θ.
- To create an angle measure:
  1. From the **Build** menu, point to **Measure**, point to **Angle**, and then select **New**.
  2. In the **Measure Name** text box, enter **pend_angle**.
  3. Right-click the **First Marker** text box, point to **Marker**, and then select **Pick**.
  4. On the screen, pick a marker that is on the pendulum and at its end (for example, select the cm marker).

     Tip: Right-click the end of the pendulum to select the cm marker.
  5. Right-click the **Middle Marker** text box, point to **Marker**, and then select **Pick**.
  6. Pick a marker that is at the pivot location.

WORKSHOP – ONE DOF PENDULUM

7. Right-click the **Last Marker** text box, point to **Marker**, and then select **Pick**.
8. Pick the marker that is on the ground and at the end of the pendulum (this is the marker that you created in the previous section, .pendulum.ground.angle_ref).

   Note: By aligning the marker .pendulum.ground.angle_ref with the cm marker, the initial value of the measure will be zero.
9. Select **OK**.

WORKSHOP – ONE DOF PENDULUM

- Specify initial conditions

  In this section, you'll specify the following joint initial conditions:

  - Displacement initial condition θ_0 = 30º
  - Initial velocity condition $\dot{\theta}_0$ = 300º/sec

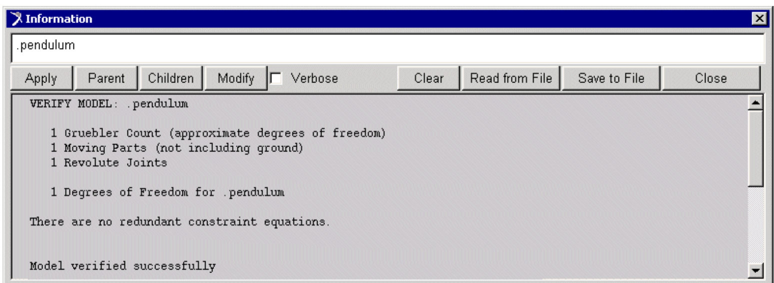
- To specify the initial conditions:

  1. Right-click the **pivot** joint, point to **Joint:pivot**, and then select **Modify**.
  2. Select **Initial Conditions**.
  3. In the Joint Initial Conditions dialog box:
     - Select **Rot. Displ** and, in the **Rot Displ.** text box, enter **-30**.
     - Select **Rot. Velo.** and, in the **Rot Velo.** text box, enter **-300**.
  4. Select **OK** in both dialog boxes.

WORKSHOP – ONE DOF PENDULUM

- Verify your model
  - Before simulating your model, verify it.
- To verify your model:
  1. Select the **Verify** tool (from the **Status** bar, right-click the **Information** tool stack).

     The Information window appears as shown next:

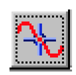
     You also receive a warning that the initial conditions for the joint position does not match the design configuration. This is what we expect.
  2. Close the Information window.

WORKSHOP – ONE DOF PENDULUM

- Simulate your model
  - Run a simulation for 2 seconds.
- To simulate your model:
  - Run a simulation for 2 seconds with 100 steps, just as you did in Simulate the model, in Workshop 3.

WORKSHOP – ONE DOF PENDULUM

- Determine global components
  - Now, determine the global components (x, y) of the initial force supported by the pivot. Use the value to answer Question 1 in Module review.
- To determine global components:
  1. Right-click the blank area inside the **pend_angle** stripchart, point to **Plot: scht1**, and then select **Transfer to Full Plot**.

     ADAMS/PostProcessor replaces ADAMS/View.
  2. Select the **Plot Tracking** tool  .
  3. Move the cursor over the plot at **t =0**.
  4. In the area below the main toolbar, note the value of Y.
  5. In the dashboard, select **Clear Plot**.
  6. Set **Source** to **Measures**.
  7. From the **Measure** list, select **pivot_force_x**.
  8. Select **Surf**.

WORKSHOP – ONE DOF PENDULUM

9. Move the cursor over the plot at **t = 0**.
10. In the area below the main toolbar, note the value of Y.
11. From the **Measure** list, select **pivot_force_y**.
12. Move the cursor over the plot at **t = 0**.
13. In the area below the main toolbar, note the value of Y.

WORKSHOP – ONE DOF PENDULUM

- Determine the frequency of the pendulum
  - Estimate the frequency by determining the period (seconds) and then inverting that value to obtain Hertz. This is the answer to Question 2 in Module review.
- To determine frequency:
  1. From the **Measure** list, select **pend_angle**.
  2. Estimate the period of the curve.
  3. Invert the period to find Hertz.
  4. Return to ADAMS/View.
  5. Save results as **Joint_res**.
  6. Save the curves on all three strip charts by right-clicking each curve, and then selecting **Save curve**.

WORKSHOP – ONE DOF PENDULUM

- Save your work

  To save your work:

  1. Use the **Save As** option to save your modeling session as a binary file. This file will contain not only the model information, but also the results and plots.

     If you want to further explore the model, as suggested in the next section, leave the model open. Otherwise, proceed with the next step.

  2. Exit ADAMS/View.

WORKSHOP – ONE DOF PENDULUM

- Optional tasks
  - Save your work before performing these tasks. Do not save your work after performing these tasks. If you must save the model after performing these tasks, give the model a different name.
- To find the frequency of the pendulum automatically by performing a Fast Fourier Transformation (FFT) on the plot of theta versus time:
  1. Run a simulation using the following settings:
     - End time = 1.65 (approximate time of one period)
     - Steps = 127
  2. In ADAMS/PostProcessor, from the **Plot** menu, select **FFT**.

     The FFT dialog box appears.

WORKSHOP – ONE DOF PENDULUM

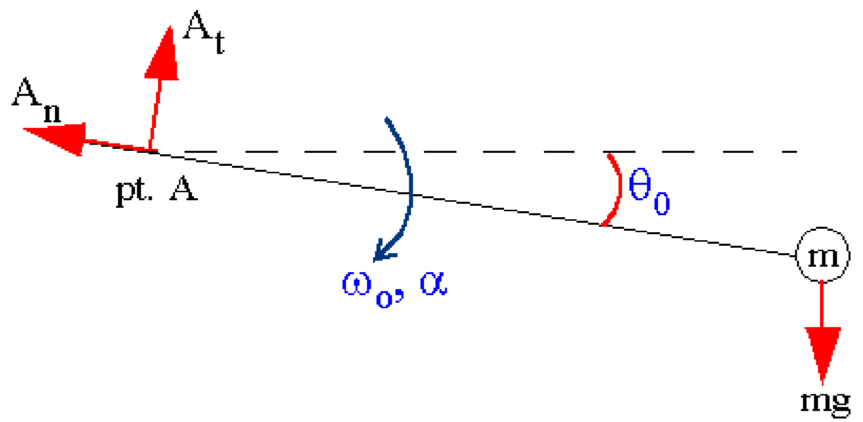
3. When preparing for an FFT operation, we recommend that:
   - The number of points be an even power of two (for example, 128, 256, 512, and so on). By solving the equation and asking for 127 steps, you will get 128 data points; 127 + 1 for the initial conditions.
   - You set **Window Type** to **Rectangle**.
   - You select **Detrend Input Data**.
4. To perform the FFT, select **Apply**. To learn more about these values, press **F1**.

   You should get approximately the same frequency as you did by calculating it manually.

   The peak value of the resultant curve is at the natural frequency.
5. Return to ADAMS/View.
6. Exit ADAMS/View.

WORKSHOP – ONE DOF PENDULUM

- MSC.ADAMS results
  - Horizontal force supported by the pivot at A = -A_n cos 30.
  - Vertical force supported by the pivot at A = A_n sin 30.
- Closed-form solution



$$I_A = I_{zz} + mr^2$$

$$I_A = 0 + mL^2$$

$$\omega_0 = 300°/sec$$

$$\omega_0 = 5.24 \text{ rad/sec}$$

WORKSHOP – ONE DOF PENDULUM

- The analytical solution for the force supported by the pivot at A when $\theta_0 = 30^o$ and $\omega_0 = 300$ degrees/sec:

$$\Sigma M_A = I_A\alpha \qquad -mg(L\cos 30) = (mL^2)\alpha$$

$$g\cos 30 = L\alpha$$

$$\alpha = -\frac{g}{L}\cos 30$$

$$\alpha = -18.88\,\text{rad/sec}^2$$

$$\Sigma F_t = mr\alpha \qquad mg\cos 30 - A_t = mL\alpha$$

$$A_t = m(g\cos 30 - L\alpha)$$

$$A_t = 0\text{N}$$

$$\Sigma F_n = mr\omega^2 \qquad A_n - mg\sin 30 = mL\omega^2$$

$$A_n = m(g\sin 30 + L\omega^2)$$

$$A_n = 34.53\text{N}$$