ADAMS Assignment 5

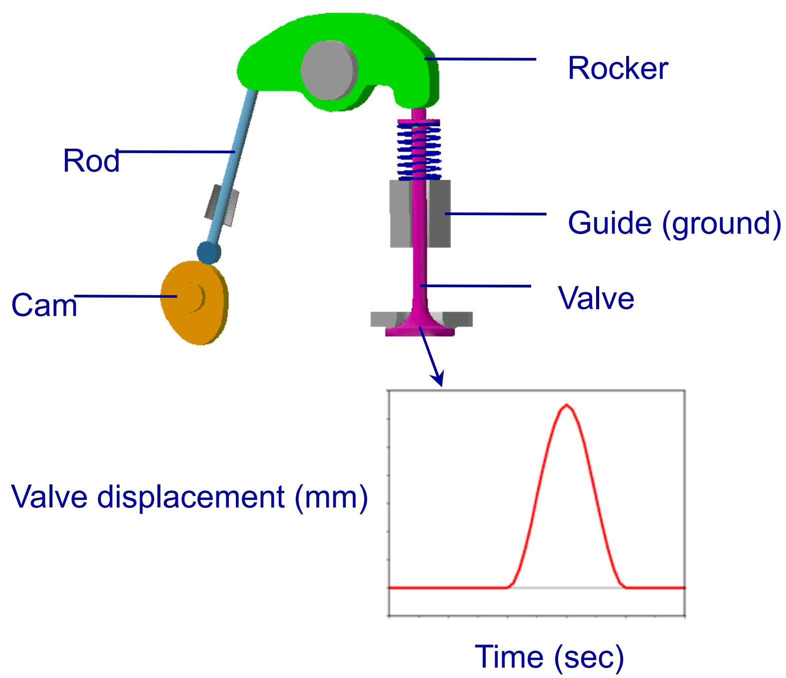
ME451:Kinematics and Dynamics of Machine Systems

Turning in Your Assignment

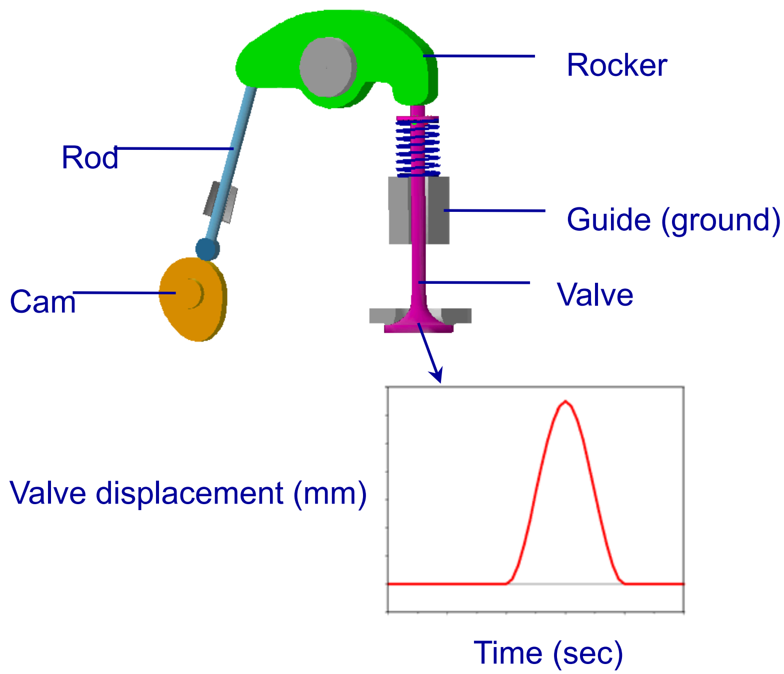
- Create a single PDF file, named “lastName_ADAMS_05.pdf” with the information listed on the last slide (including the supporting plots).
- Make sure your name is listed on that file.
- Drop the file in the appropriate Dropbox Folder (ADAMS_05) at Learn@UW

The file **valve_train_start.zip** is available for download on the class website.

CAM-ROCKER-VALVE



- Problem statement
  - Design a cam profile based on desired valve displacement, and ensure that there is no follower liftoff when the cam is rotated at 3000 rpm.



- Model description
  - The model represents a valvetrain mechanism.
  - The cam is being rotated at a velocity of 1 rotation per second.
  - The rocker pivots about a pin attached to the engine block (ground).
  - The valve displaces up and down as the rocker moves.
  - When the valve moves, it lets small amounts of air in the chamber below it (not modeled here).

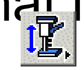
    Note: At the location of the translational joint, between the valve and ground, the model includes a spherical dummy part. You will use this dummy part when you make the valve a flexible part. This dummy part will not affect the rigid body dynamics.

1. Open ADAMS/View from some working directory
2. Import the file **valve_train_start.cmd**.

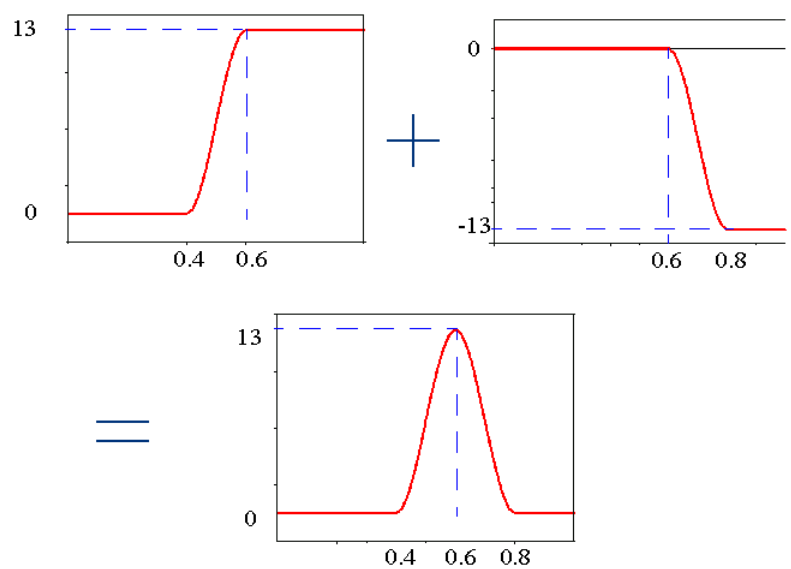
   The file contains a model named **valve_train**.

- Apply motion

To apply motion:

1. Use the **Translational Joint Motion** tool  to add a motion to the joint, **Valve_Ground_Jt**, such that its displacement appears as shown next:

   Add two STEP functions.

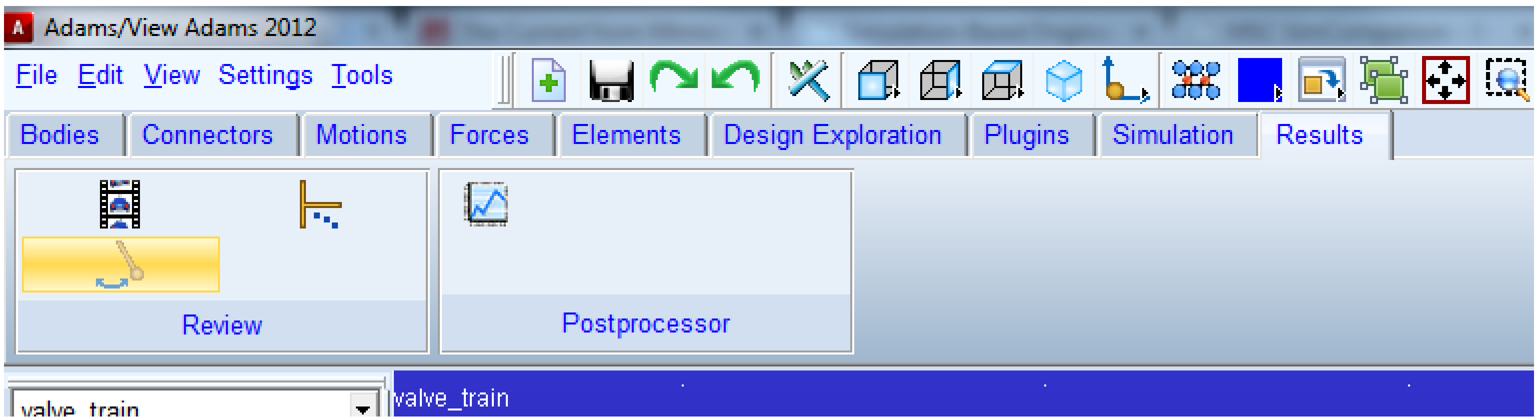


Tip: The functions should look as follows:
STEP(time, .4, 0,.6,13)+ STEP(time,.6,0,.8,-13).

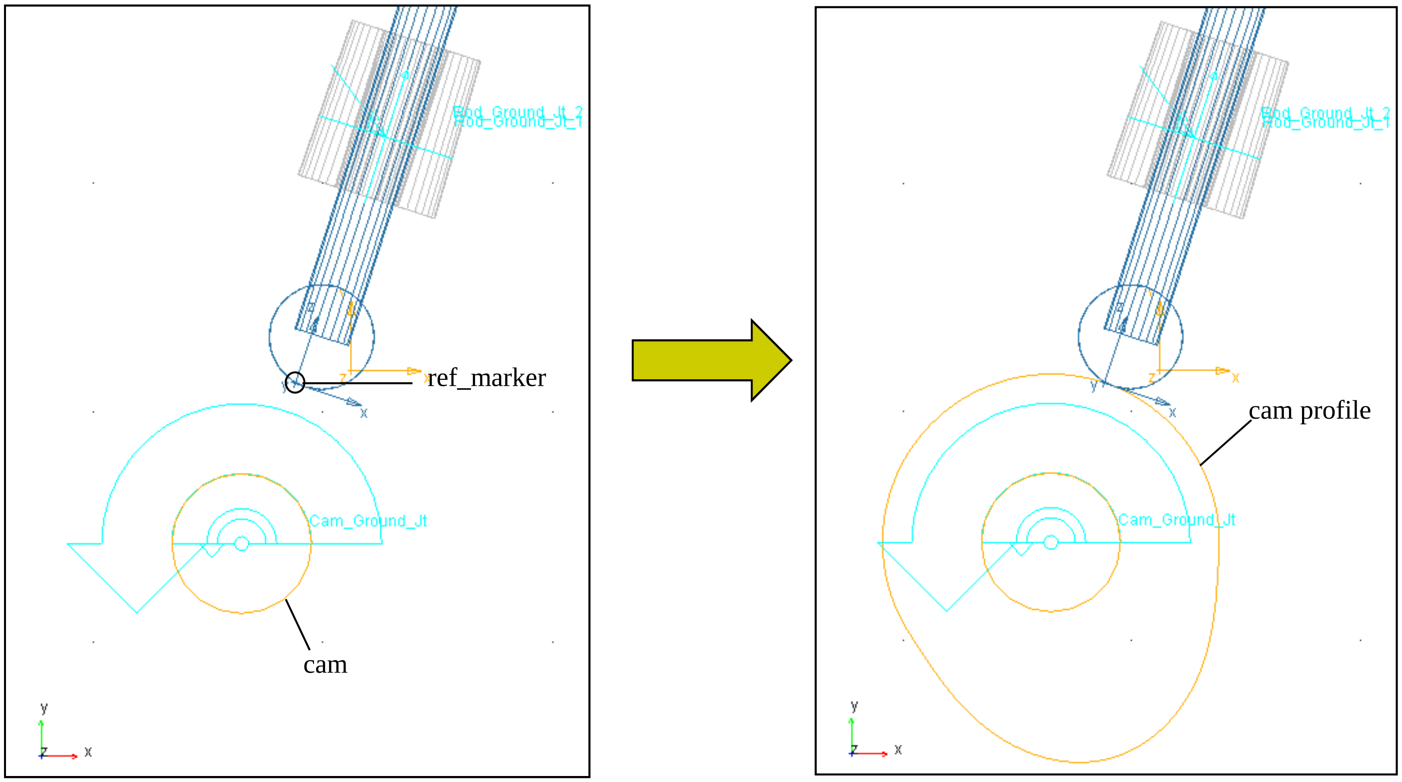
2. Run a **1-second**, **100-step** simulation to verify that the valve displaces as a result of the joint motion.

- Create a cam profile
  - Use a point trace to create a cam profile.
- To use a point trace:
  1. From the **Results tab → Review** menu, select **Create Trace Spline.**

     NOTE: You must run the 1 second test simulation to use this feature!



  2. Select the circle on the rod (**rod.CIRCLE_1**) and then the part named **cam**.
  3. Verify that you now have a spline representing the cam profile.

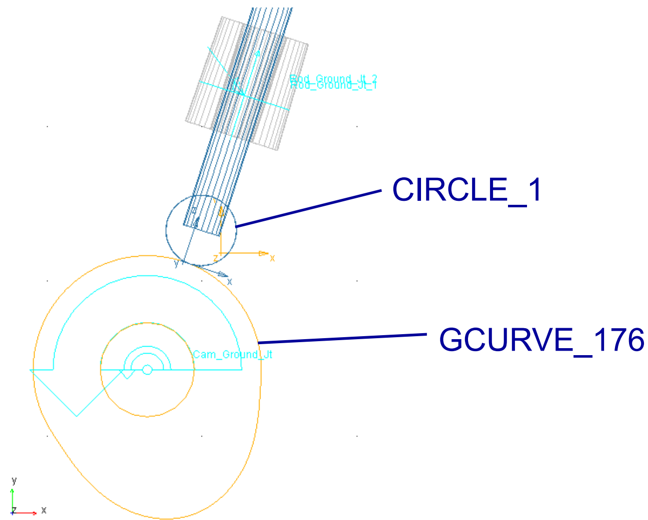


4. Run a simulation to verify that the **Rod** appears to move along the surface of the **Cam**.

- Constrain the rod to the cam

To constrain the rod:

1. Delete (or deactivate) the joint motion you created on the translational joint, **Valve_Ground_Jt**.
2. Use the **Curve-Curve Constraint** tool to create a curve-on-curve constraint between the circle on the **Rod** and the cam profile on the **Cam**.



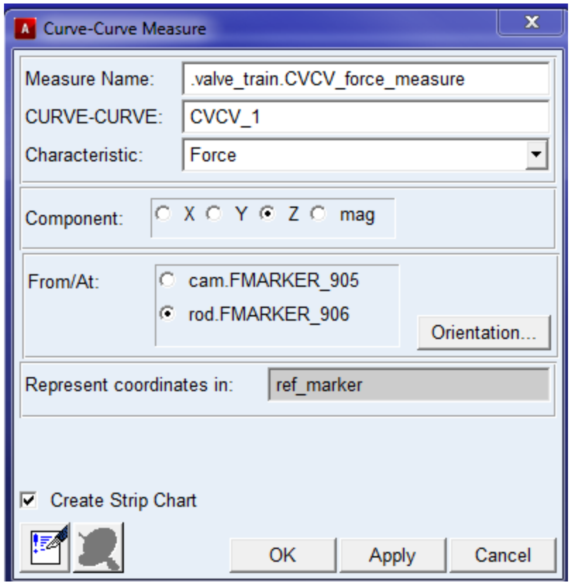
3. Run a simulation to verify that the new constraint works.

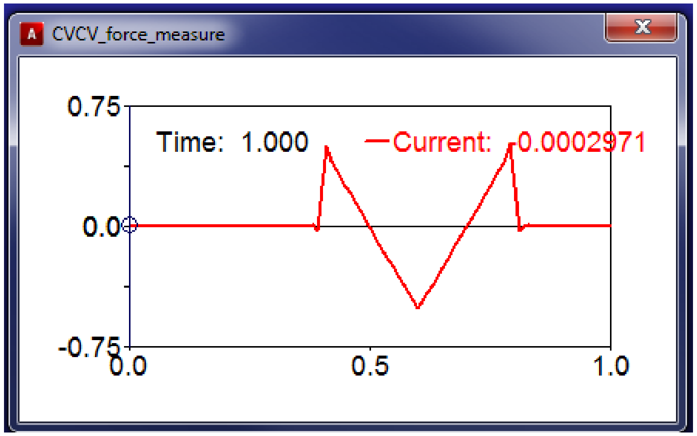
- Measure the force in the curve-on-curve constraint

  To measure the force:

  - Create a force measure for the curve-on-curve constraint (right-click the constraint and then select **Measure**). Measure the force along the z-axis of **ref_marker**, which belongs to the rod:
    - **Characteristic**: **Force**
    - **Component**: **Z**
    - **Represent coordinates in**: **ref_marker**

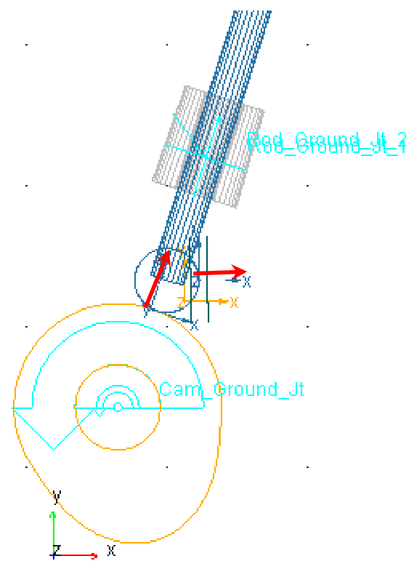
    The curve-on-curve constraint applies a negative force that keeps the rod follower on the cam, avoiding any liftoff.





- Make the cam-to-rod contact more realistic
  - Now you'll replace the curve-on-curve constraint with a curve-to-curve contact force.
- To replace the curve-on-curve constraint:
  1. Deactivate the curve-on-curve constraint you created in Step 2 on slide 10.
  2. Create a contact, on **Force tab → Special Forces**, and then select **Create a contact**

3. Use the following contact parameters:
   - Contact Name: rod_cam_contact
   - Contact Type: Point to Curve
   - Marker: ref_marker
   - J Curve: the Trace spline you created on the cam body
   - Use the Change Direction tool to make sure that the normal arrows point outward from the curve, as shown next:

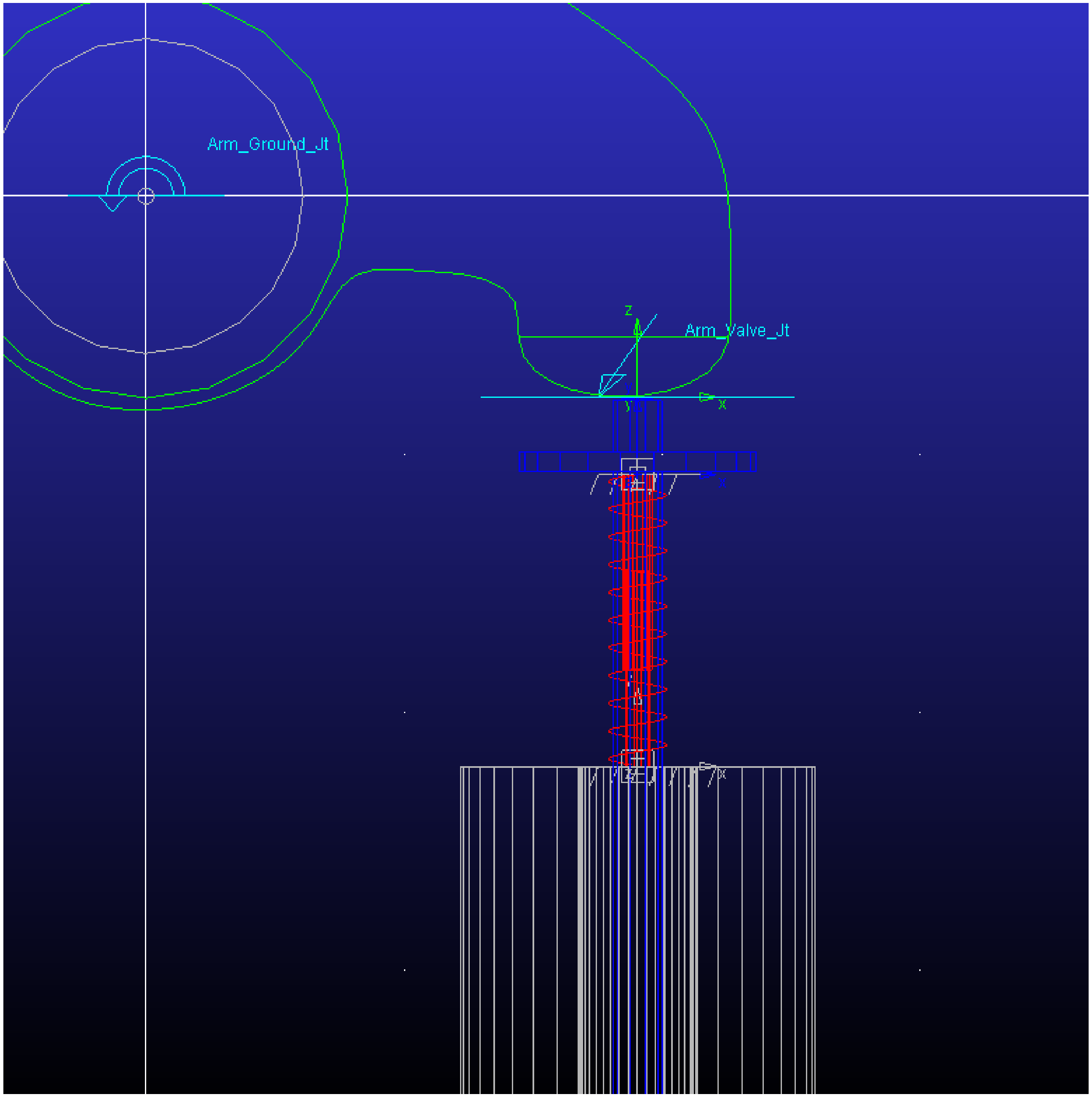


- **Normal Force**: **Impact**
  - **Stiffness (K)**: **1e6 (N/mm)**
  - **Force Exponent (e)**: **1.5**
  - **Damping (C)**: **10 (N-sec/mm)**
  - **Penetration Depth (d)**: **1e-3 mm**
  - **Friction Force**: **Coulomb**
  - **Coulomb Friction**: **On**
  - **Static Coefficient** (μ_s): **0.08**
  - **Dynamic Coefficient** (μ_d): **0.05**
  - **Stiction Transition Vel.** (v_s): **1 (mm/sec)**
  - **Friction Transition Vel.** (v_t): **2 (mm/sec)**
- Run a simulation to check if liftoff occurs.

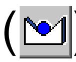
- Prevent liftoff using a spring damper

  To prevent liftoff:

  1. Add a marker on the valve at the location, **Valve_Point**:
     - **Add to Part**
     - From the screen, select body: **valve** and the location: **Valve_Point**.
  2. Add a spring damper between the marker you just created and the point, **Ground_Point** (which is a point on ground, at the top of the guide) using the following parameters:
     - **Stiffness (K)**: **20 (N/mm)**
     - **Damping (C)**: **0.002 (N-sec/mm)**
     - **Preload**: **400 N**
  3. Your spring should look like the one shown on the next slide



Arm_Ground_Jt
Arm_Valve_Jt

3. Find the static equilibrium of the model (). It can be found in **Simulation → Simulate →Run an Interactive Simulation**

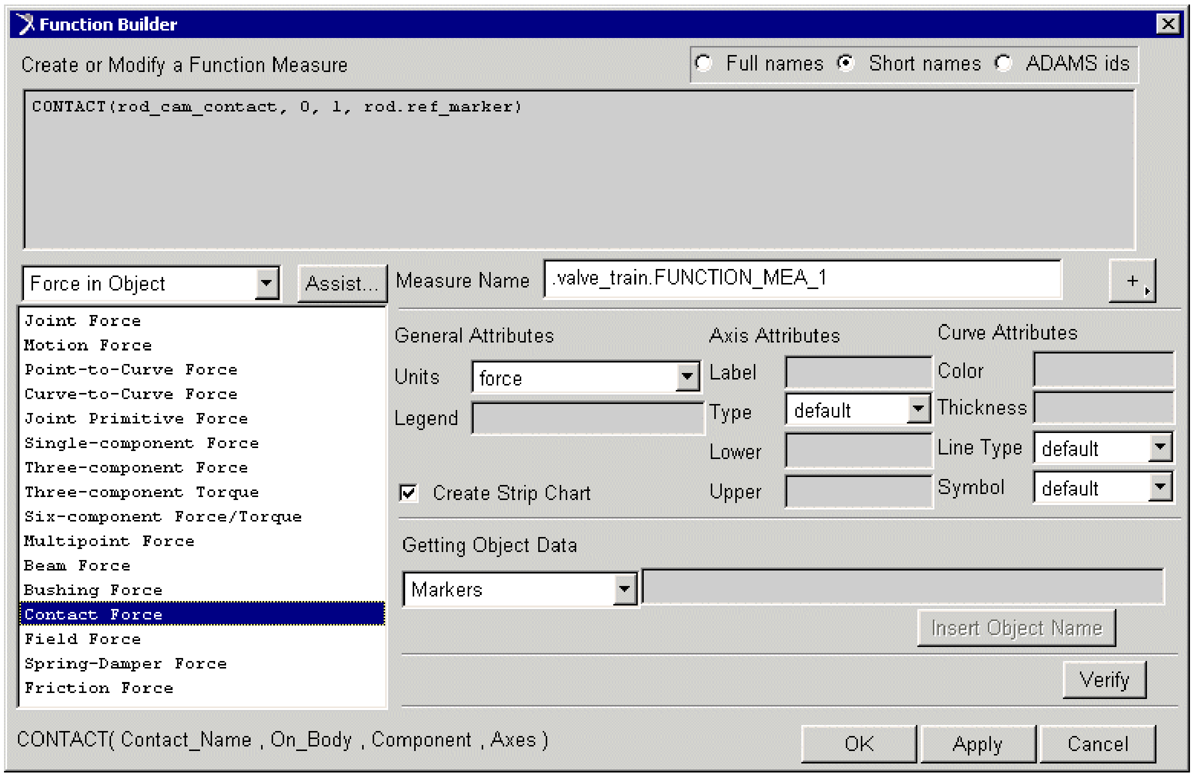
   Do not reset the model before going on to the next step.

   Note: You perform the static equilibrium to eliminate the transient effect that results from the time-dependent damping characteristic of the spring damper. In addition, positioning the model in static equilibrium establishes initial contact between the roller and the cam.
4. Run a dynamic simulation to view the effects of the spring starting from static equilibrium.
5. Modify the rotational motion on the cam to a speed of **3000 rpm**. Enter the function as follows: **-50*360d*time**.
6. To view only one rotation of the cam, run a static equilibrium followed by a dynamic simulation for **end=1/50 seconds**, **steps=100**. An easy way to run this simulation sequence is to create a simulation script.

7. Measure the contact force by creating a function **(Design Exploration → Measures → Create a new Function Measure).**

- **Category**: **Force in Object**

Note: Make sure you measure the contact force using the **rod.ref_marker** as the reference plane, as shown below:



8. Rerun the simulation to populate the new measure stripchart.
9. Modify the spring-damper characteristics (stiffness, damping, and preload) to prevent liftoff based on the new rotational speed of the cam.

Question A: Experiment with different values for spring stiffness until the no-lift criteria is met. (or try to get as low lift-off as possible) Do ***not*** change the preload and damping properties.

- **Preload**: **400 N**
- **Damping (C): 0.002 (N-sec/mm)**

- Report on your chosen spring stiffness, and the ratio of lift-off reduction (e.g., time(reduced lift-off) / time(original lift-off)
  - Report this value on the forum

10. Save the model.

- Questions
  1. How many DOF are removed by adding a curve-on-curve constraint?
  2. Calculate the travel distance between two extreme positions of the valve when a curve-on-curve constraint is used (e.g., what is the vertical distance the valve displaces during a single cam cycle?)
  3. How many DOF are removed by adding a curve-to-curve force?

- What should you turn in?

  1. Answers to Question A (previous slide), and 1 through 3.
  2. Also, turn in the plots (if needed) to support your answers.