# ES 204
Mechanical Systems Lab #1

In this lab you will be preparing a working model simulation that you will use later in the course when you do the third lab. This lab is also intended to give you an introduction to Working Model and some practice in using the program. Be sure to save the working model simulation you generate on your hard disk.

Meterstick Falling

The third laboratory in this class will involve a measuring the velocity at the end of a meterstick as it falls down a wall as shown below. The purpose of this part of the lab is to generate a fairly generic working model simulation of the experiment so you will be able to compare your experimental results to the working model results.
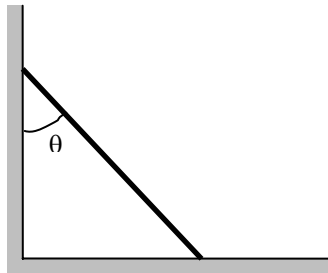
Creating the geometry

Be sure the units you are using are metric and degrees (View/Numbers and Units). It is often convenient to turn on a grid and axes (View/Workspace)

1. Create a rectangle that will be the ground and one that will be the wall. Both should be at large enough to accommodate the motion of the meterstick. Anchor both rectangles down and make sure the corner between the two objects is at (0,0). The dimensions of the objects can be changed by bringing up the geometry window (Window/Geometry). The positions can be changed by bringing up the property window. Obviously the positions and dimensions can be changed by clicking and dragging, but often the windows are more convenient.

Should be at 0,0
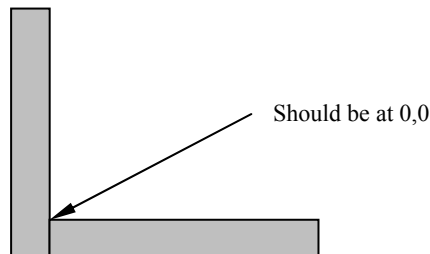
2. Create a meter stick (h=1 m). Estimate the thickness, w, and mass. These can easily be changed later. You can change the thickness using the geometry window.
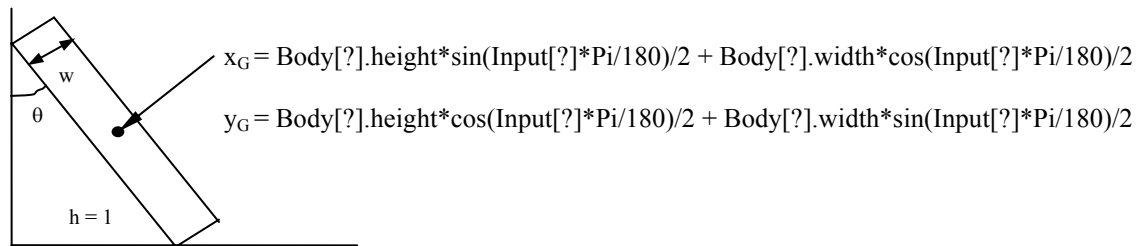
Add Sliders

You'll want to add some sliders to your simulation so it will be easy to change quantities such as the coefficient of kinetic and static friction (μ_k & μ_s), and the initial starting angle (θ).

1. Angle Slider

Highlight the meterstick and create a new control for its initial rotation (θ). Note this will be the rotation as measured ccw from the positive y-axis. Double click on the text of the slider and then modify the range to be 0 to 90°. Be sure to note the name of the slider also. It should be something like "Input[4]".

We will now use this slider to not only control the angle of the meterstick, but also the position. Bring up the property menu (Ctrl I or double click on an object). Highlight the meterstick or use the selector at the top of the property menu to select the correct object. We now need to input a formula for the x and the y locations of the bar so that it will just be touching both walls. Be sure you understand where how the equations shown below were derived.

$$x_G = Body[?].height*\sin(Input[?]*Pi/180)/2 + Body[?].width*\cos(Input[?]*Pi/180)/2$$

$$y_G = Body[?].height*\cos(Input[?]*Pi/180)/2 + Body[?].width*\sin(Input[?]*Pi/180)/2$$

After entering the formula, moving the slider should also reposition the meterstick so that is always touching both walls. Make sure this is the case. Run the simulation to make sure everything seems to work. If the meterstick appears to go through the ground you may need to change the accuracy of the simulation.

2. Friction sliders (make a slider that can control the static and the kinetic friction between all the objects)

Select one of the rectangles and create a new slider for static friction and a new slider for kinetic friction. Change the names to be "Kinetic Friction" and "Static Friction". This can be done by bringing up the Appearance menu and double clicking on the text of the sliders. After you have sliders, go to each of the bodies in the problem and input the correct formula in the "kinetic friction" and the "static friction boxes".

3. Metrics

We now want to generate some plots. Select the meterstick and ask for a plot of the angular rotation (Measure/Position/Rotation graph). Highlight the graph and look at its properties. Ask it to plot the angular velocity and the angular acceleration of the meterstick on the same plot. This is done by inputting names and equations in y2 and y3. The equations should be similar to the one for the position except they should be Body[?].v.r and Body[?].a.r. You may also want to change the colors of the lines so that you can easily distinguish the angular velocity from the angular acceleration. This is easily done from the appearance menu.

Answer the questions on the worksheet.

Worksheet

Names   _____   _____

Questions for falling meterstick

What mass did you use for the meterstick? _____

For $\mu_s = \mu_k = 0.3$ what angle does the rod start to slip? _____

Is the angular acceleration of the rod a constant? Sketch what it looks like.

Did you have some discontinuities near t=0? If so, why?

Release the rod at $\theta = 10°$ with $\mu_s = \mu_k = 0$. At what angle (approximately) does the left end of the rod leave the vertical wall? Hint: It might be helpful to measure the contact force. To do this, simply select both the wall and the yardstick before going to the "measure" menu. You will also need to step through the simulation one step at a time. Numerical values for the angle can be obtained from the plot by clicking on the box in the upper left-hand corner. If your time steps are too large to get an accurate determination of the angle change the step size in "World/Accuracy"

Set $\mu_s = \mu_k = 0.7$ and the angle of the rod at 20°. Now, change μ_s (and μ_k) and determine the smallest μ_s so that the rod will not slide?

Other comments or observations:

Staple to this page a snapshot of the working model simulation after you have made a run.