Haptic Pen STM & Atomic Force Simulation Software Loading Instructions

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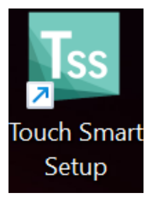
1 General Instructions

If you do not already have the tool kit, driver, LabVIEW, and other software required to use the Haptic Pen, please follow the steps provided on our Getting Started Guide. This will include downloading the "Haptic-Programming-Interface" and "LabVIEW-VIs" folders. These two folders should have the following paths:

C:\Users\[username]\Documents\GitHub\Haptic-Programming-Interface

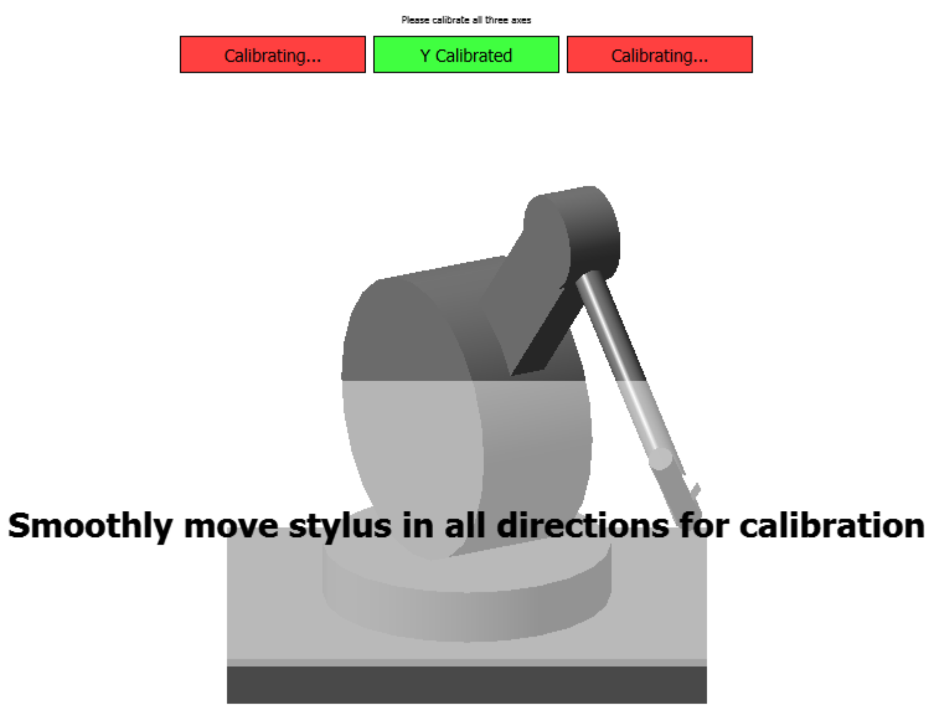
C:\Users\[username]\Documents\GitHub\LabVIEW-VIs

The documents folder must not be in OneDrive for this to load properly. Prior to loading any of the LabVIEW programs, you must initialize the Haptic Pen using the Touch Smart Setup at the following shortcut or at the following path



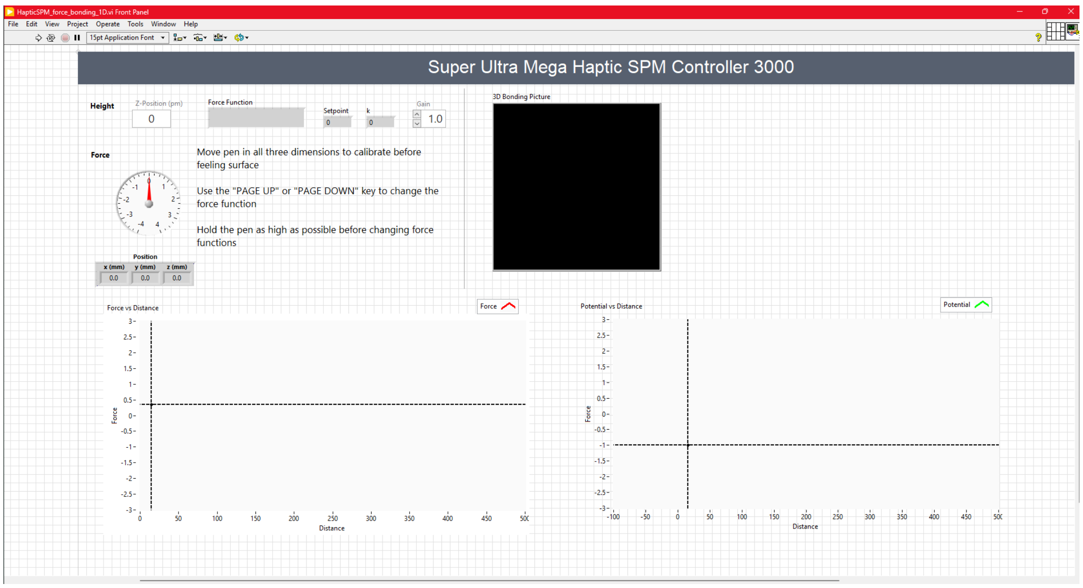
C:\Program Files\3D Systems\Touch Device Drivers

Then calibrate the Haptic Pen by moving in all three dimensions until each XYZ is green.

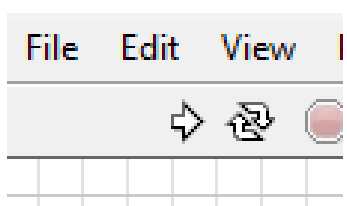


2 1D Atomic Force Simulation

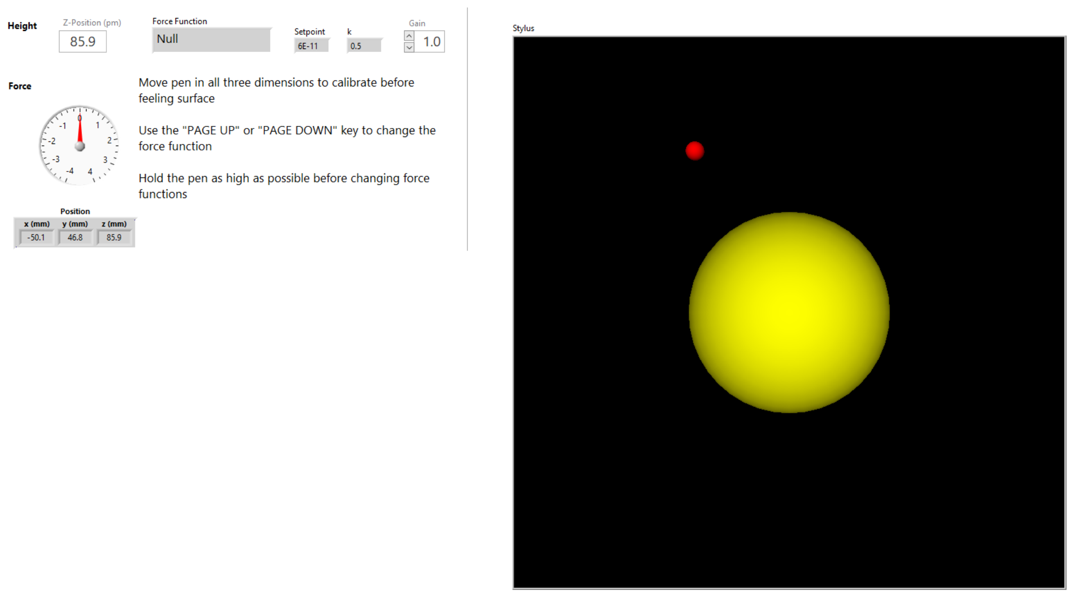
1. Navigate to the "LabVIEW-VIs" folder and enter the "Force Mode" folder.
2. Double click to enter the "HapticSPM_force_bonding_1D.vi" file. The path for this file should be "C:\Users\[username]\Documents\GitHub\LabVIEW-VIs\Force Mode\HapticSPM_force_bonding_1D.vi"
3. The startup screen (front panel) will look like the following. A larger screen allows for a better view of each of the components of the program.



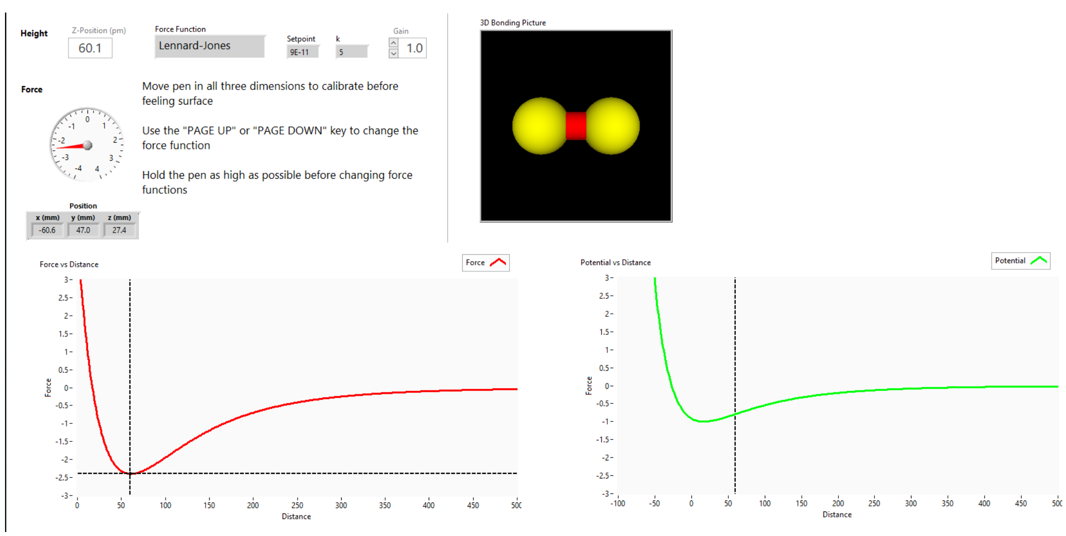
4. In the top left corner, the little white arrow turns on the program. It will loop indefinitely until the red stop sign is clicked. Make sure to lift the pen as high as possible and move it around to re-calibrate and initialize.



5. The program will begin with a demo of how the pen works by placing a haptically accessible sphere halfway in a box. The red cursor on the diagram shows the live location of the pen in reference to the sphere. The force associated with this is the spring force, specifically Hooke's law. Thus pushing deeper into the sphere returns force at a rate of $F = -kx$.



6. The program navigates through each of the forces, including the demo described above, using the "PAGE UP" and "PAGE DOWN" keys. The forces in this program are, in order, the short ranged "Covalent Attractive" force, the "Coulombic Repulsive" force, the "Coulombic Attractive" force, and the "Lennard-Jones" potential force.



7. The left graph shows the force versus distance and the right graph shows potential versus distance.

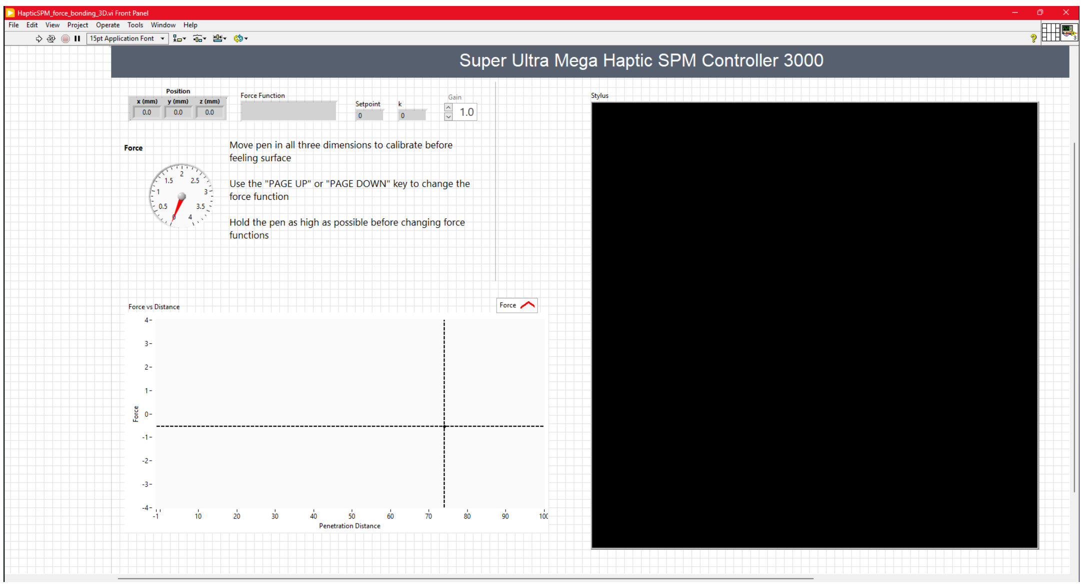
8. In the "Lennard-Jones" force function, which is the R-12/6 force, there are three regimes of the force. The first is the free space regime at the top of the pen's range. There are no forces acting on the pen in this regime. The second regime is the attractive regime, which is in the middle of the pen's range and leads into the potential well. The final regime is the repulsive regime which prevents the pen from slipping up out of the well and is at the bottom of the pen's range.

3 3D Spherical Atomic Force Simulation

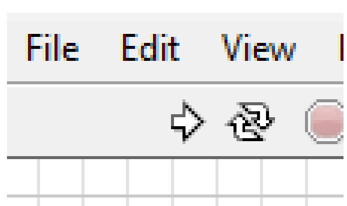
1. Navigate to the "LabVIEW-VIs" folder and enter the "Force Mode" folder.

2. Double click to enter the "HapticSPM_force_bonding_3D.vi" file. The path for this file should be "C:\Users\[username]\Documents\GitHub\LabVIEW-VIs\Force Mode\HapticSPM_force_bonding_3D.vi"

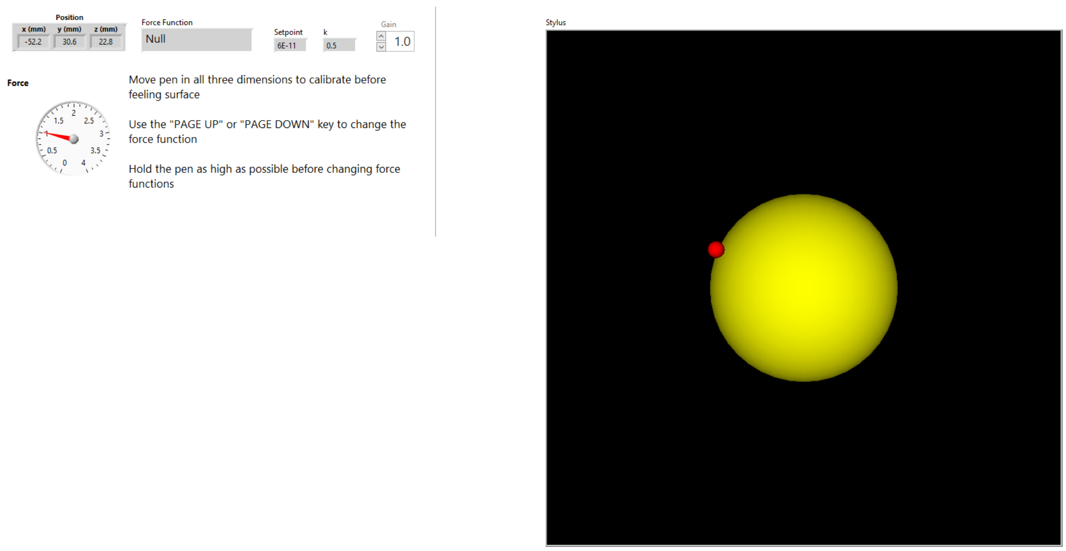
3. The startup screen (front panel) will look like the following. A larger screen allows for a better view of each of the components of the program.



4. In the top left corner, the little white arrow turns on the program. It will loop indefinitely until the red stop sign is clicked. Make sure to lift the pen as high as possible and move it around to re-calibrate and initialize.



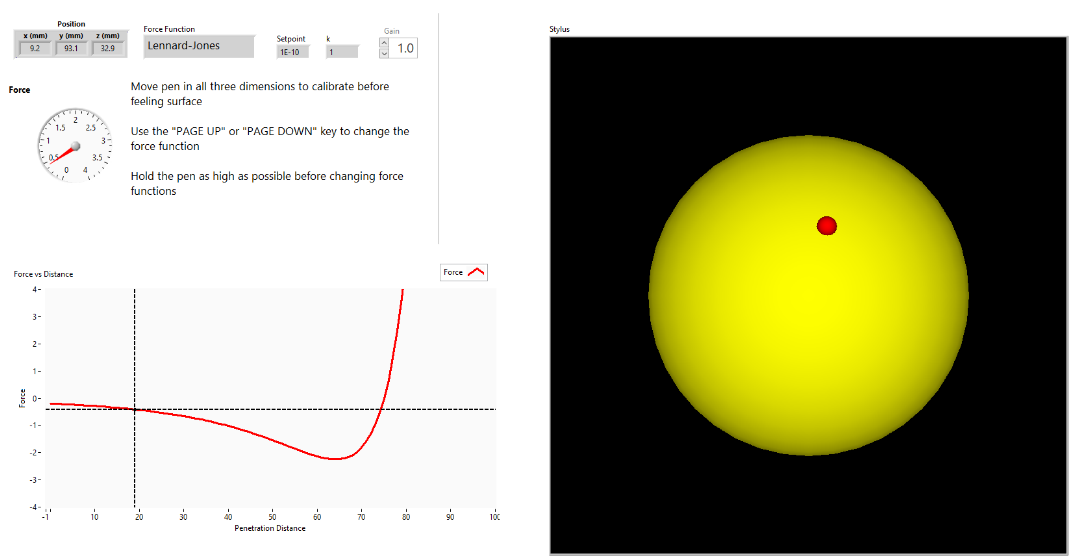
5. The program will begin with a simple sphere accessible on all sides via the spring force (Hooke's law, $F = -kx$). The red stylus shows the live position of the pen in relation to the sphere.



6. The program navigates through each of the forces, including the demo described above, using the "PAGE UP" and "PAGE DOWN" keys. The forces in this program are, in order, the "Coulomb Repulsion" force and the "Lennard Jones" force.

7. The "Coulomb Repulsion" force uses the inverse square law to increase the repulsive force as you bring the pen closer to the center of the simulated sphere.

8. The "Lennard-Jones" force will begin in the attractive regime and pull the pen into an equilibrium radius of the sphere, at which point the force becomes repulsive and prevents entry into the simulated nucleus. The nuclear radius is an exaggerated 25% of the total radius of the sphere.

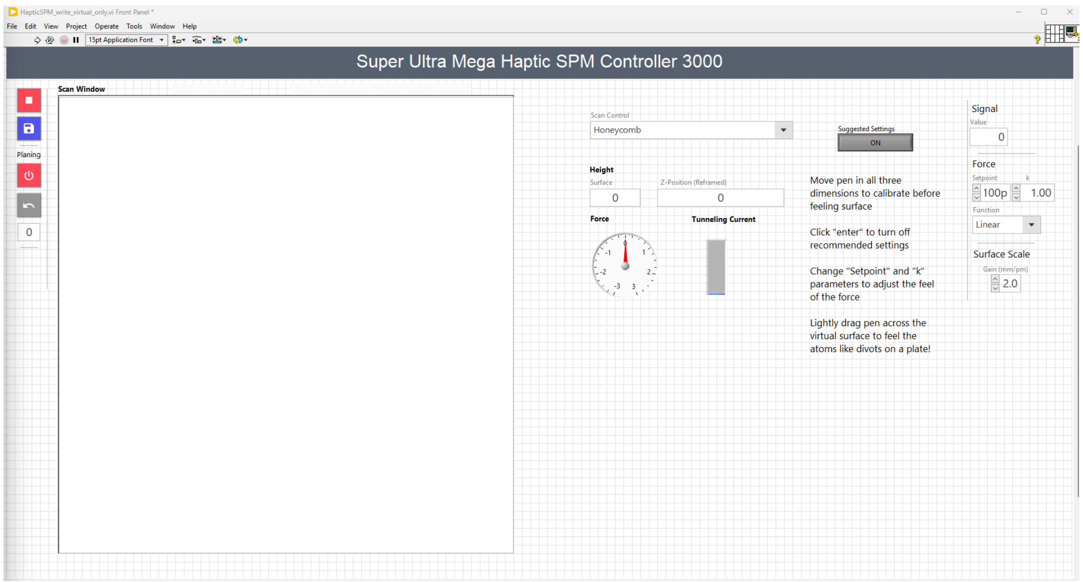


4 STM Simulation

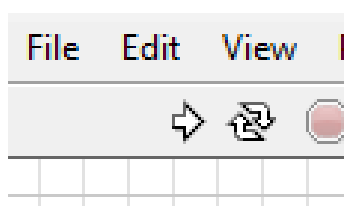
1. Navigate to the “LabVIEW-VIs” folder and enter the “Write Mode” folder.

2. Double click to enter the “HapticSPM_write_virtual_only.vi” file. The path for this file should be “C:\Users\[username]\Documents\GitHub\LabVIEW-VIs\Write Mode\HapticSPM_write_virtual_only.vi”

3. The startup screen (front panel) will look like the following. A larger screen allows for a better view of each of the components of the program.



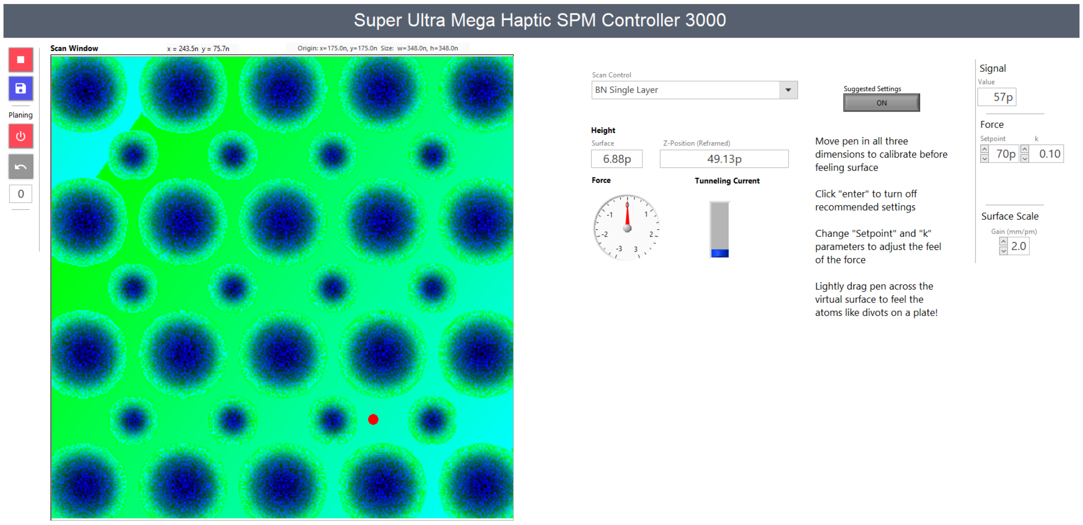
4. In the top left corner, the little white arrow turns on the program. It will loop indefinitely until the red stop sign is clicked. Make sure to lift the pen as high as possible and move it around to re-calibrate and initialize.



5. The program has different maps accessible via the “Scan Control” toggle box. The red cursor shows the live XY position of the pen in relation to the map. The blue wells represent the decrease in tunneling current associated with the non-conducting atoms or molecules on a conductive plate.

6. To interface with the map, find the conductive (green) surface with the cursor and bring the pen straight down towards the table until you feel a surface pushing back against the pen as if you are resting on a virtual flat surface. Then lightly drag the pen across the surface and feel the pen dip into the wells when you travel across.

7. When traveling into and out of the wells, you may feel a jump in the force; this is due to the boundary of a conductive versus a non-conductive surface. The plate should feel hard while the atoms feel squishy.



8. The first three options in the Scan Control, "Honeycomb", "Honeycomb (Small)", and "BN Single Layer", are optimized simulated data. These will have distinct differences between the surface and the atoms on them.

9. The other three options in the Scan Control, "WSe2", "One Defect", and "Two Defects", are real data collected by the STM. These will have less of an exaggerated distinction between the atoms and the plate.

10. It is important in the STM Simulator mode to not push too hard into the surface. The Haptic Pen will reach a maximum of 4 newtons of force, and the topographic map relies on a difference in heights to create the sensation of feeling the wells. Pushing too far down on the pen may result in a constant 4 newtons being applied to the pen, regardless of its XY position around a well.