Basic AFM Checklist

1) Turn on the super luminescent diode (SLD) by switching the key on the front of the SPM controller to the On position.

2) Turn on the camera light source by adjusting the small remote dial to about 50%.

3) Mount your sample either on a piece of glass or a magnetic puck (?), and secure it in place with magnets.

4) Load a tip (See figure 1)

   a. Load tip holder into loading apparatus (Figure 1A), which offers stability when loading tips.

   b. Loosen tongue clamp screw.

   c. Slide probe chip under tongue clamp. Position cantilevers so that they are centered (more or less) in the clear trapezoidal shaped quartz optical window (Figure 1B & C). For best results, DO NOT push probe chip substrate all the way back in the pocket: it can cause the probe chip to lift off the floor of pocket, compromising the deflection signal (i.e., no signal), see Figure 1D.

   d. Tighten the screw in the center of the stainless steel tongue assembly (NO MORE THAN finger tight!).

5) Put cantilever holder into the MFP-3D™ head. Make sure the cantilever holder is parallel to the top of the head; otherwise it is not properly seated.

6) Place head on scanner.

   a. Lift the head with two hands and place the back two legs in the machined divots on the MFP-3D baseplate (Figure 2A).

   b. Move hands so thumbs are under the front of the head, and slowly lower head towards stage using back legs as pivot point; continually monitoring the tip – sample separation (Figure 2B). If it looks as though the tip will crash, lift the head back up and adjust height with the thumbwheel in the front
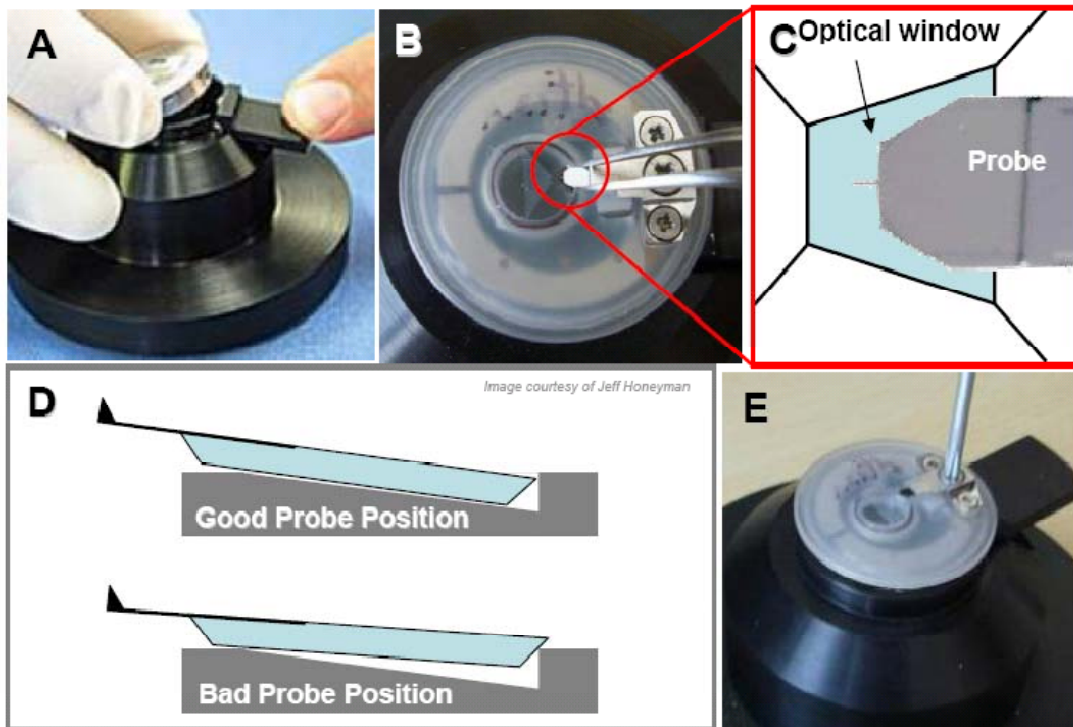

Figure 1. How to load a cantilever. A) Loading the cantilever holder into the cantilever holder stand. B) Use tweezers to position cantilever in middle of polished quartz window. C) Proper position of probe in quartz window. D) Proper position of probe in pocket; if too far back, probe slides on back ledge of pocket compromising deflection signal; E) Tighten screw on tongue clamp- *no more than finger tight*.

to increase the tip-sample separation and then carefully lower the head.

7) Align the SLD on the cantilever.

a. Make sure the CCD window is open in the Asylum software. ▣ Press Source if you get a blue screen.

b. Using the two SLD adjustments dials on the head (see Figure 3), find the SLD spot and make sure that it is on the tip. (You may need to adjust the x or y position of the CCD camera with the two knobs at the very back of the head to bring the tip into the camera's view.) See Figure 4 for the appropriate position of the SLD spot on the cantilever.

c. While positioning the SLD on the cantilever, make sure that the sum signal (in the sum and Deflection meter in the Asylum software) is maximized.

8) Zero the 'Deflection' voltage signal in the S&D meter. The top of the head is labeled to tell you what way to go to see a positive or negative change (see Figure 3; label 'C').
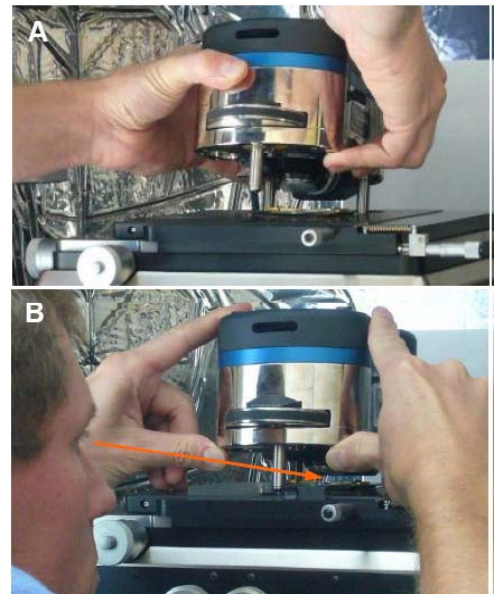
Figure 2. Installing the head onto base plate over sample. A) use two hands to lift head, set back two legs onto base plate first; B) gently lower front leg down, constantly monitoring tip sample distance to avoid tip crash.
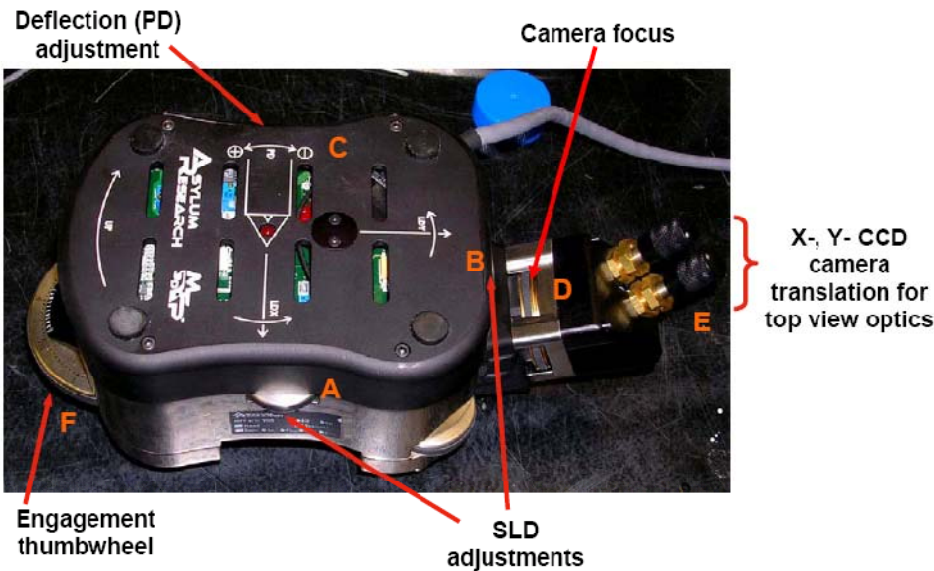

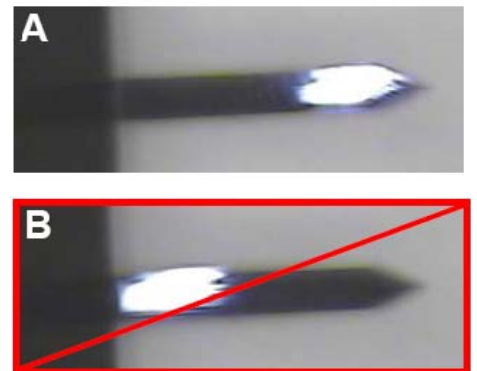Figure 3. AFM head with the various alignment thumbwheels labeled.

Figure 4. Align the SLD spot towards end of cantilever to maximize optical lever sensitivity; A) shows the correct position of the spot B) shows spot at base of cantilever, which would yield low optical lever sensitivity.

9) Tune the tip
   a. From the Main tab in the Master Panel, confirm that 'AC mode' is selected from the imaging mode pull-down menu.
   b. Open the Tune tab of the Master Panel.
   c. The default Auto Tune 'High' and 'Low' values are ~50 kHz to 400 kHz, respectively, accommodating most (fundamental) drive frequencies for common AC mode cantilevers (in air).
   d. Choose a Target Amplitude of 1.0V.
   e. Change the 'Target Percent' to -10.0 %, which will select a drive frequency that's on the left side of the resonant peak, which helps ensure the tip will remain in repulsive mode when engaged.

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Figure 5. The Cantilever Tune window following a successful autotune procedure.

f. Click the 'Auto Tune' button.
g. You should see a plot similar to that in Figure 5. If you don't, you may need to do a thermal tune to locate the tip frequency (see Thermal tab), or your tip may be bad, in which case you should change the tip.
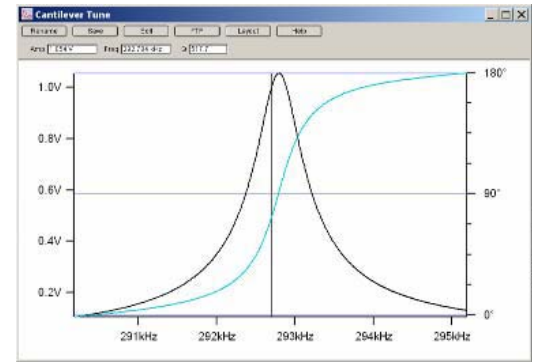
10) Soft engage the tip on the sample.

a. Notice the value of the phase shift. This is your free air phase, and you'll want to compare it to the value after you engage the tip on the sample.
b. Set the Set Point voltage for about 95% of the free air amplitude voltage (i.e., for a 1.0 V free air amplitude, use a Set Point voltage of 950 mV).
c. Click 'Engage' button.
d. Slowly turn the front thumbwheel CCW while monitoring the amplitude voltage (S&D meter), waiting for it to equal the Set Point voltage, at which point the feedback loop is engaged and you should hear a beep. (This engagement is a false engagement- the tip is engaging on the (inherent) water layer and compressed air between the tip and sample.)
e. Adjust the Z piezo voltage to ~30 to 50 V (halfway blue). You'll notice the Z piezo voltage seems to float/drift as you move the thumbwheel- that's because it's falsely engaged!
f. Decrease the Set Point voltage to increase the force; the Z piezo voltage will move to some more positive voltage value (more red). At some point, you will see a 'hard' engagement in the Z piezo. As you continue to decrease the Set Point value, you'll notice the Z piezo will no longer move to a more positive value.
g. At this point, the tip is 'hard' engaged on the surface. It has been engaged at the lowest possible Set Point force possible, therefore preserving the tip shape. It is stationary on the surface, waiting to be told to scan.
h. To check to see if you are in attractive mode or repulsive mode, look at the phase (S&D meter) and compare it to the free air phase value before you engaged the tip. If the value has decreased, you are in repulsive mode. If the value increases, you are in attractive mode.
i. If the phase increased, but you want to be in repulsive mode, increase the Drive amplitude voltage slightly, and/or decrease the set point voltage slightly. Watch the phase and see if it decreases indicating you're now in repulsive mode.
j. If the Phase doesn't stay below the initial free air Phase value, or it starts to flip all over the Phase scale (i.e., mode hopping),
    i.   Withdraw the tip
    ii. Increase the target amplitude to 1.5 V or 2.0 V
    iii. Repeat steps 9f – 10i
k. Press Withdraw, close the hood, and press Engage.

11) Once the tip is engaged on the surface, imaging can commence.

a. Click the 'Do Scan' button, or 'Frame Up' or 'Frame Down' button on the Main tab of the Master panel. This will move the tip to the corner of the scan area, and begin scanning.
b. Monitor how the tracking improves by monitoring how well the trace and retrace line scans compare to each other. Note that they do not have to overlap exactly (because they are slightly offset in the software display), but they should have similar shapes/slopes per given surface feature.
c. Adjust the Set Point voltage. Decreasing the Set Point voltage, increases the force applied to the sample. Higher Set Point voltages (lower force), will help preserve the tip apex, but may not allow proper tracking of the surface. (Adjusting the Set Point Voltage to more than 50% of the free air

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amplitude voltage doesn't really help apply more force. Beyond that, the cantilever isn't really acting as a simple harmonic oscillator anymore.)

d. The Drive Amplitude can also be adjusted to increase the amount of amplitude applied to the cantilever; advantages of increasing this can be maintaining the tip in repulsive or attractive mode, or when imaging sticky samples (the larger amplitudes help the tip escape the forces of the sample).

e. The Integral Gain should be adjusted such that the surface is tracking well; things to avoid are decreasing it to a value that doesn't allow the feedback to track the surface well, or so high that oscillations are apparent in the image and trace/retrace scan lines below the images. (When adjusting the Integral gain, monitor the amount of noise in the Amplitude Image- feedback oscillations are easily seen in the image since because it's an image of the feedback loop error. One of the best approaches to adjusting the Integral gain is to increase it until there is a 'ringing' seen in the (re)Traces lines below the height image. Then decrease it until this ringing goes away.)

f. Modify the Scan Rate, ScanAngle, Scan Size, Scan Points and Scan Lines as necessary.

12) Save your images
   a. Select the correct path to save your data by pressing the Browse button and selecting the folder in which you wish to save your data.
   b. Input a Base Name and a Base Suffix for your file name.
   c. Press the Save Image button, and it will save the image the next time it completes a full scan.

13) Shut down
   a. Press the Stop button.
   b. Use the thumbwheel to raise the head, and then lift the head onto the shelf.
   c. Remove your sample.
   d. Turn off the light and the laser.
   e. Close the software

Glossary

Sum: The sum signal of the SLD on the photodetector.

Deflection: The deflection of the signal on the photodetector. When this value is zero, the signal is centered on the photodetector, and you'll have maximum sensitivity

Amplitude: The amplitude of the tapping tip.

Phase: The phase shift of the tip movement from the drive frequency.

Z voltage: An indication of where the z-piezo is in its range. This value can range from 0-150. 0 is fully retracted (away from the sample), and 150 is fully extended (towards the sample).

Setpoint voltage: The voltage that determines how much force is applied to the sample in AC mode.

Setpoint voltages that are much smaller than the free air amplitude voltage will apply large forces. If the Setpoint voltage is larger than the free air amplitude voltage, the tip will not be engaged on the sample.

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