Lecture: P1_Wk4_L4

Processing Force Curves

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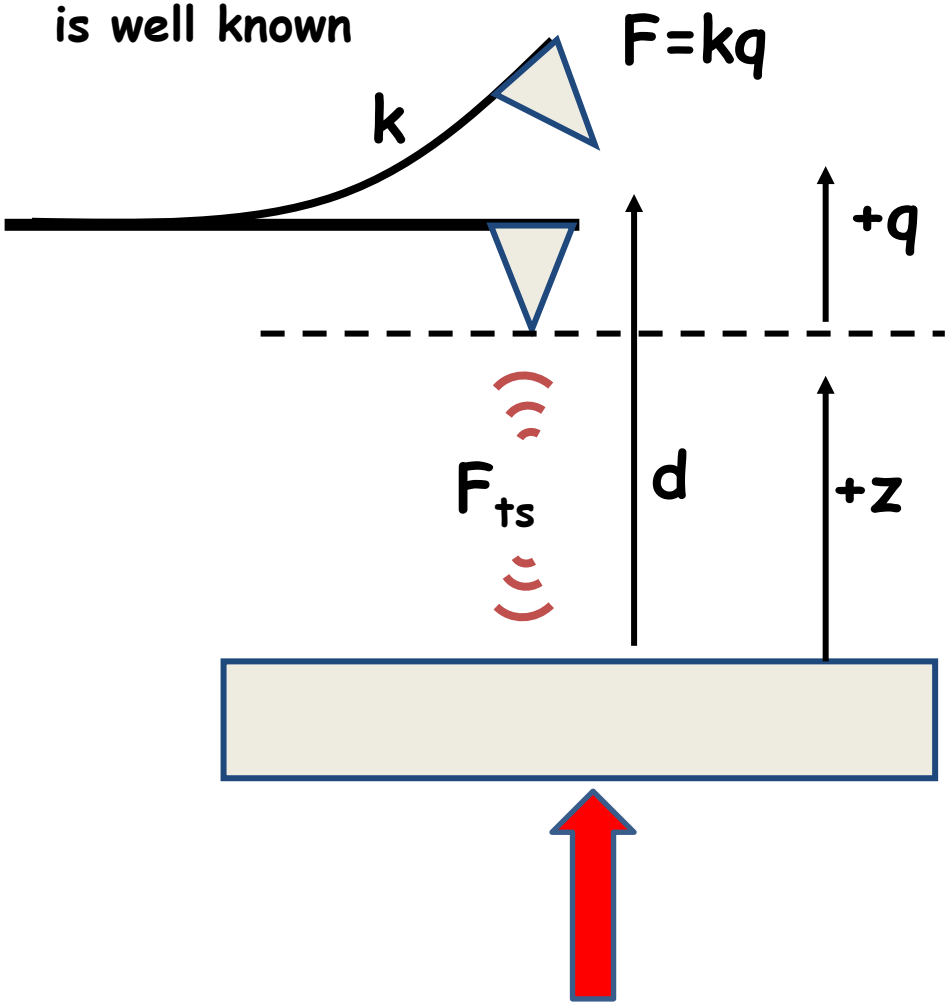
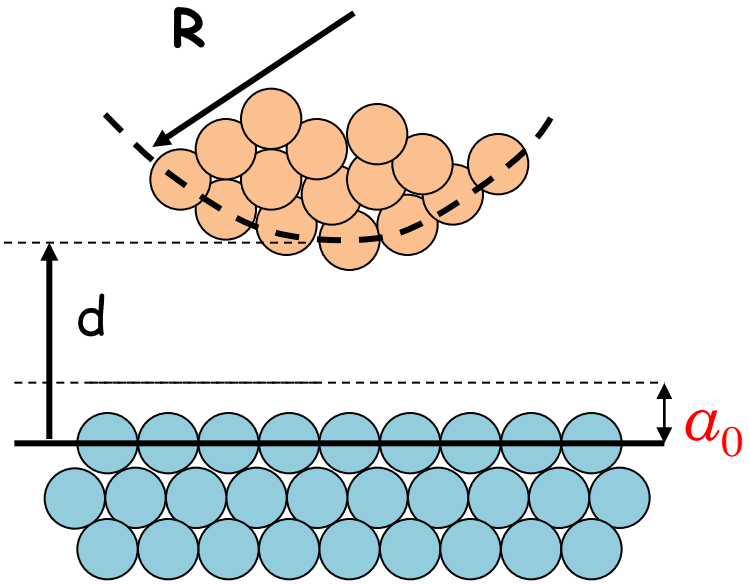
The Basic Force vs. z-Displacement Experiment

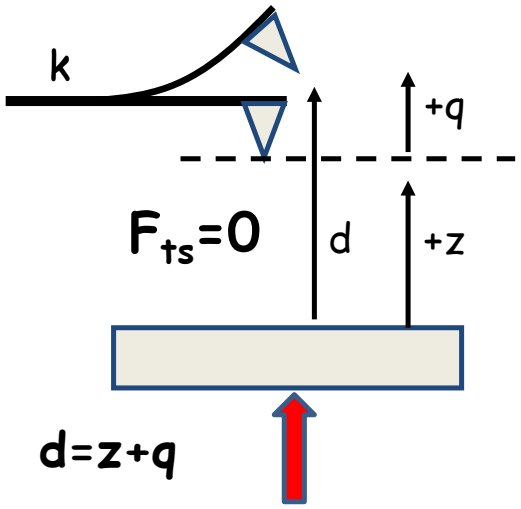
Assume that k is well known

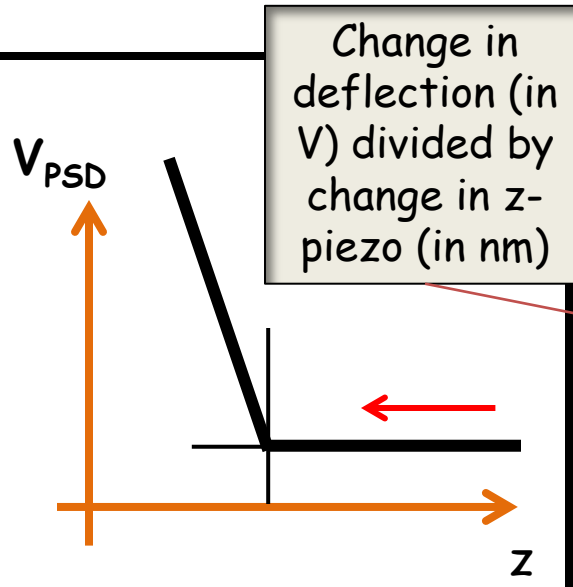


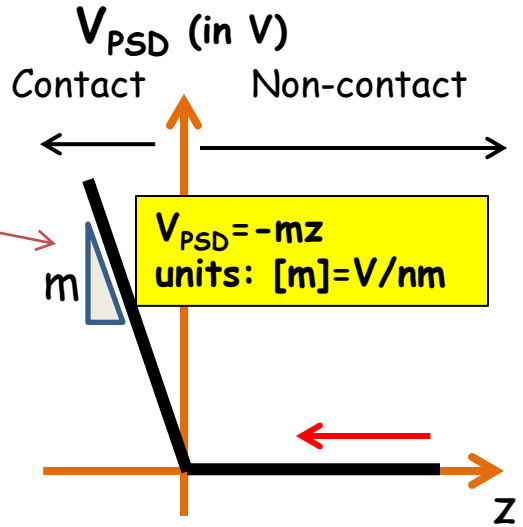


H.-J. Butt, B. Cappella, and M. Kappl, Surf. Sci. Reports **59**, 1-152 (2005).

I. Infinitely hard materials, no surface forces





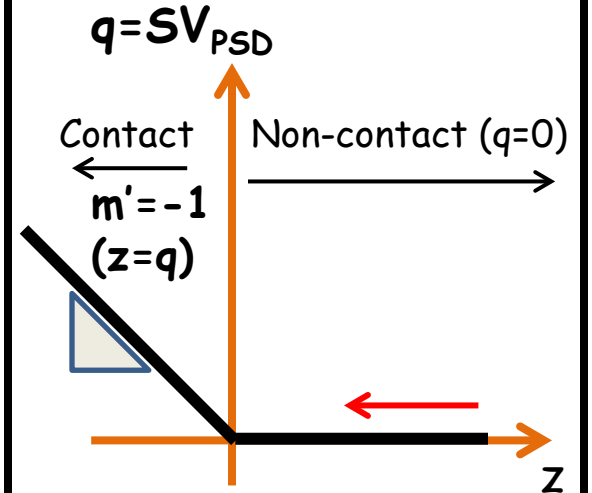


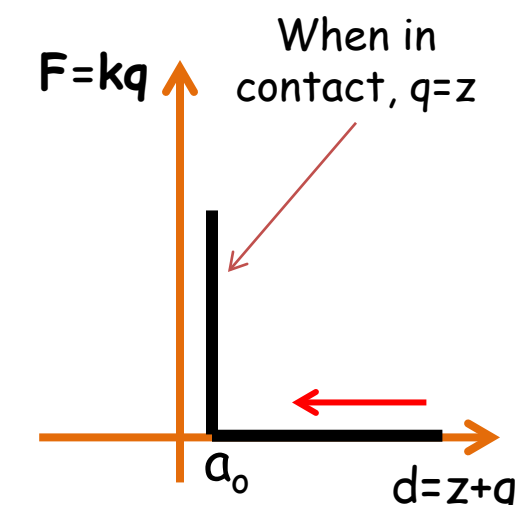
During contact: q=-z
(infinitely hard sample, no deformation: D=0)

Find S such that:
S x V_{PSD}= S(-mz)=q

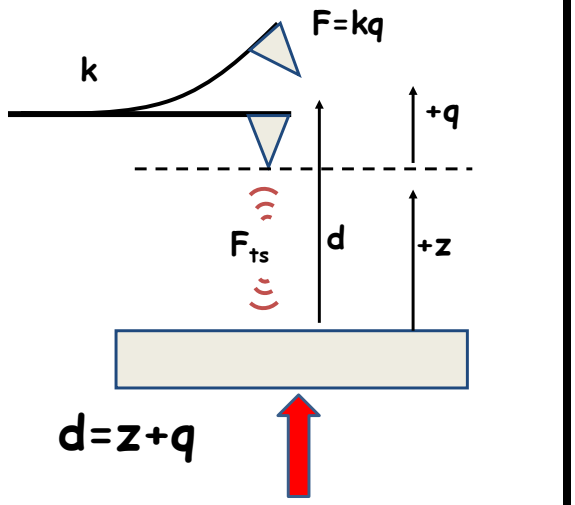
m'=-mS=-1; S=1/m

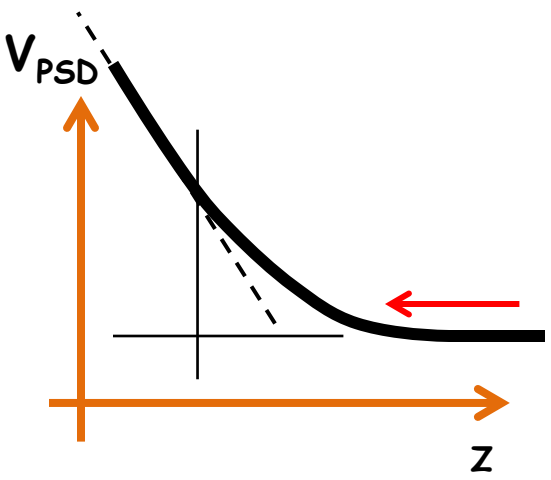
<u>Non-contact regime:</u>
convert z to d using d=z
(since q=0 because F_{ts}=0)

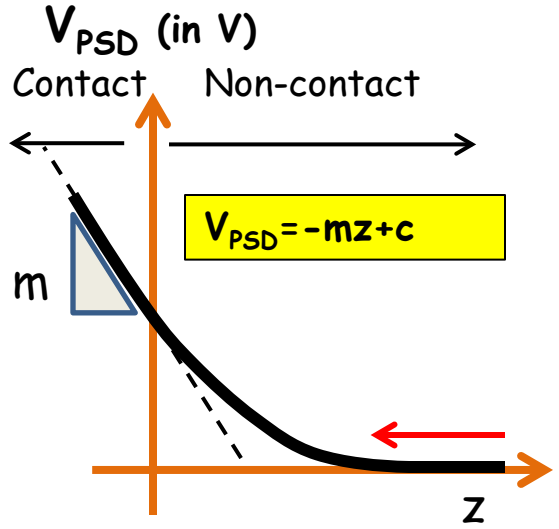




II. Infinitely hard sample/tip, repulsive surface force





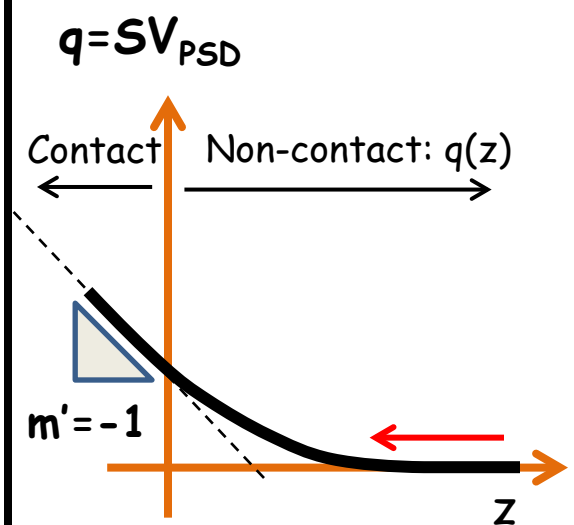


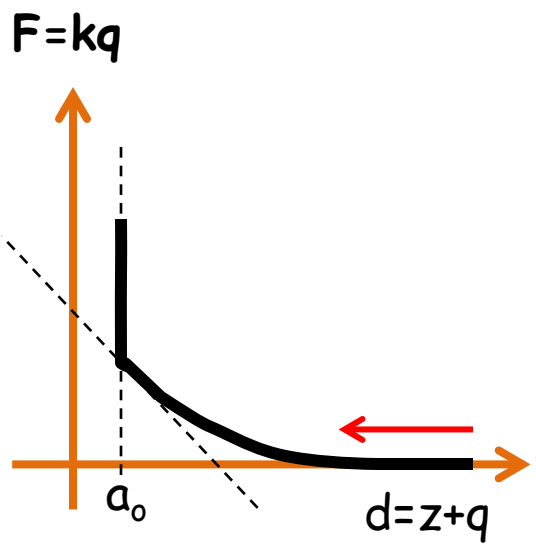
During contact: q=-z (infinitely hard sample, no deformation: D=0)

Find S such that:
S x V_{PSD}=S(-mz)=q

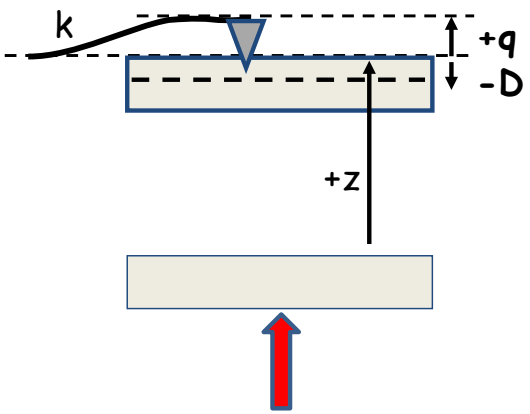
m'=-mS=-1; S=1/m

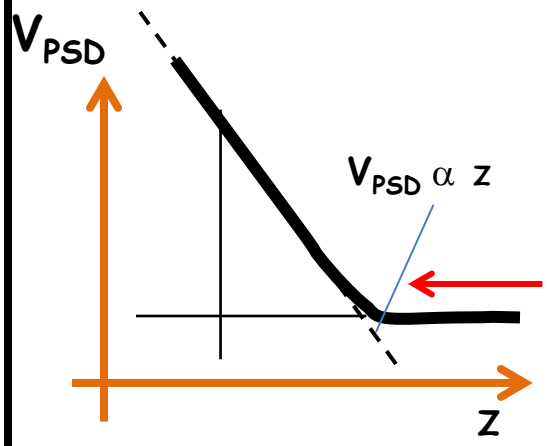
Non-contact regime: convert z to d (d=z+q)

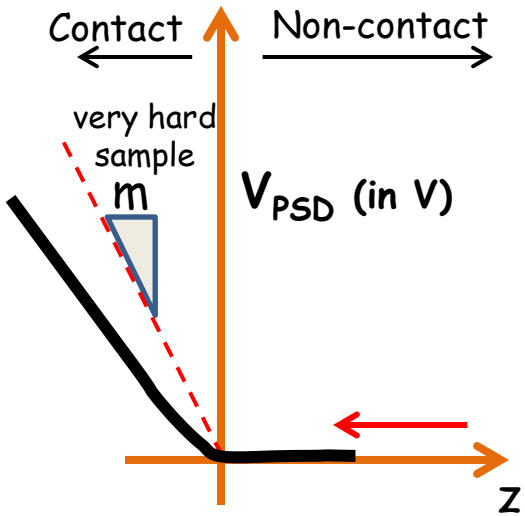




III. Soft material, no surface forces





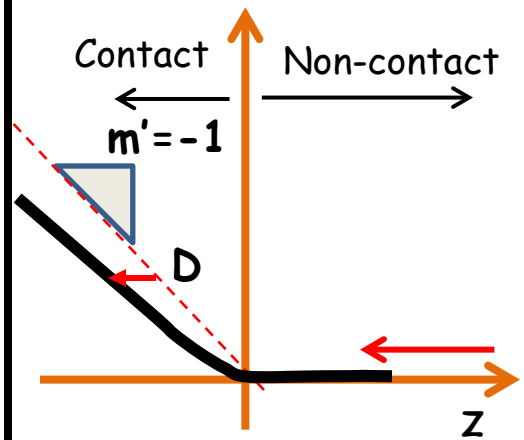


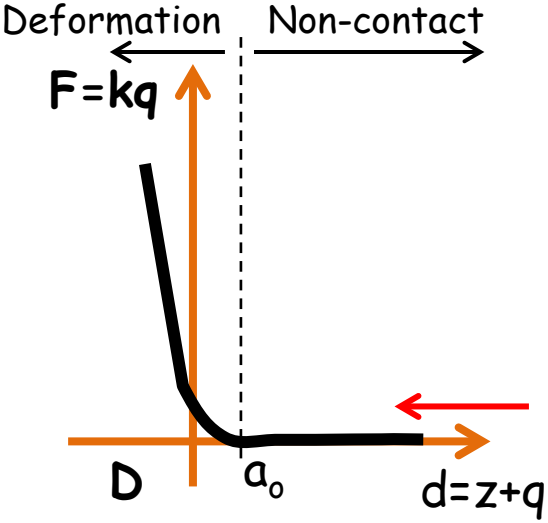
During contact: sample deforms

Find S such that:
$S \times V_{PSD} = m(-Sz) = q$

$m' = -mS = -1$; $S = 1/m$

Non-contact regime:
convert z to d (d=z+q)



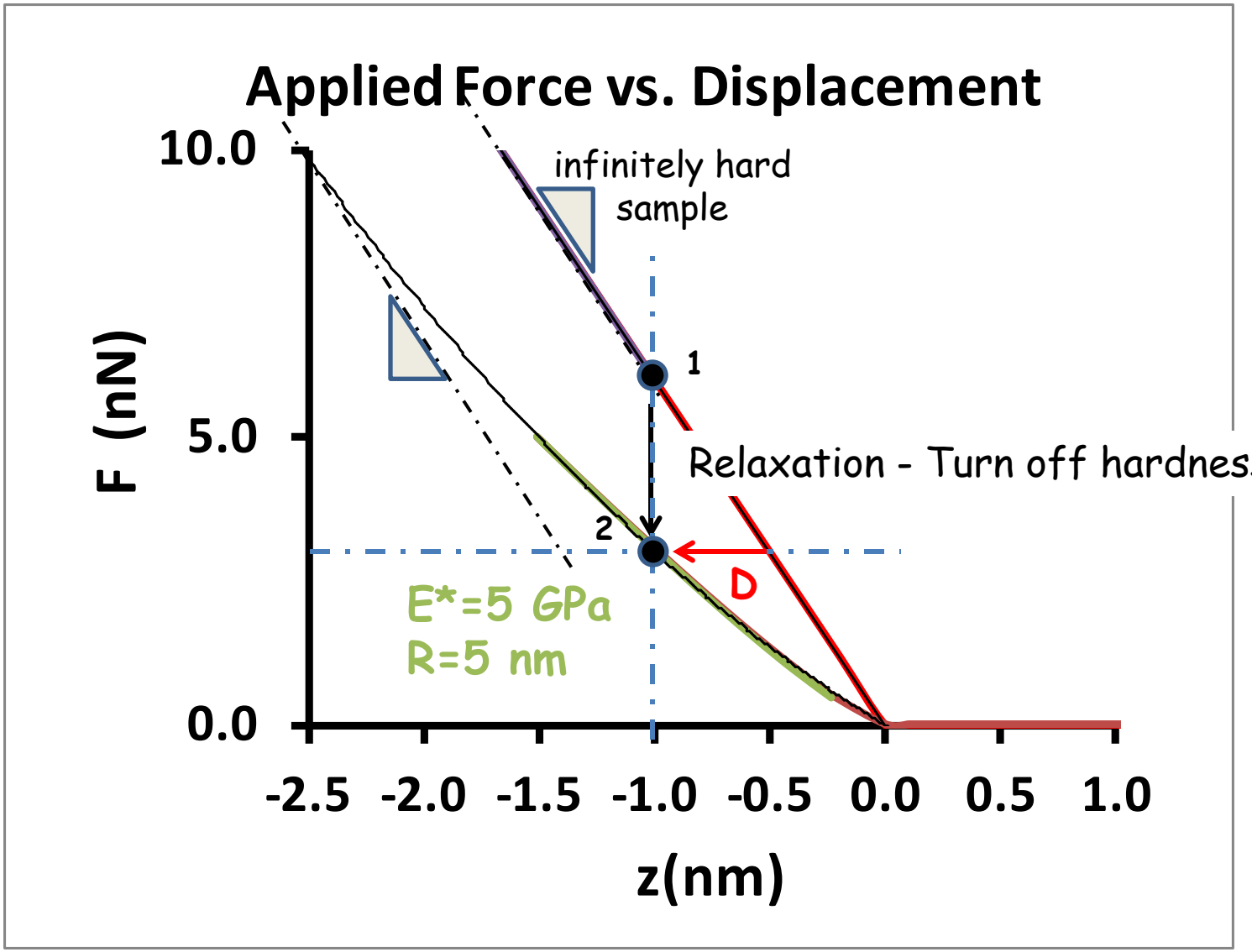


Calibration on hard sample, usually done after data acquisition on softer sample

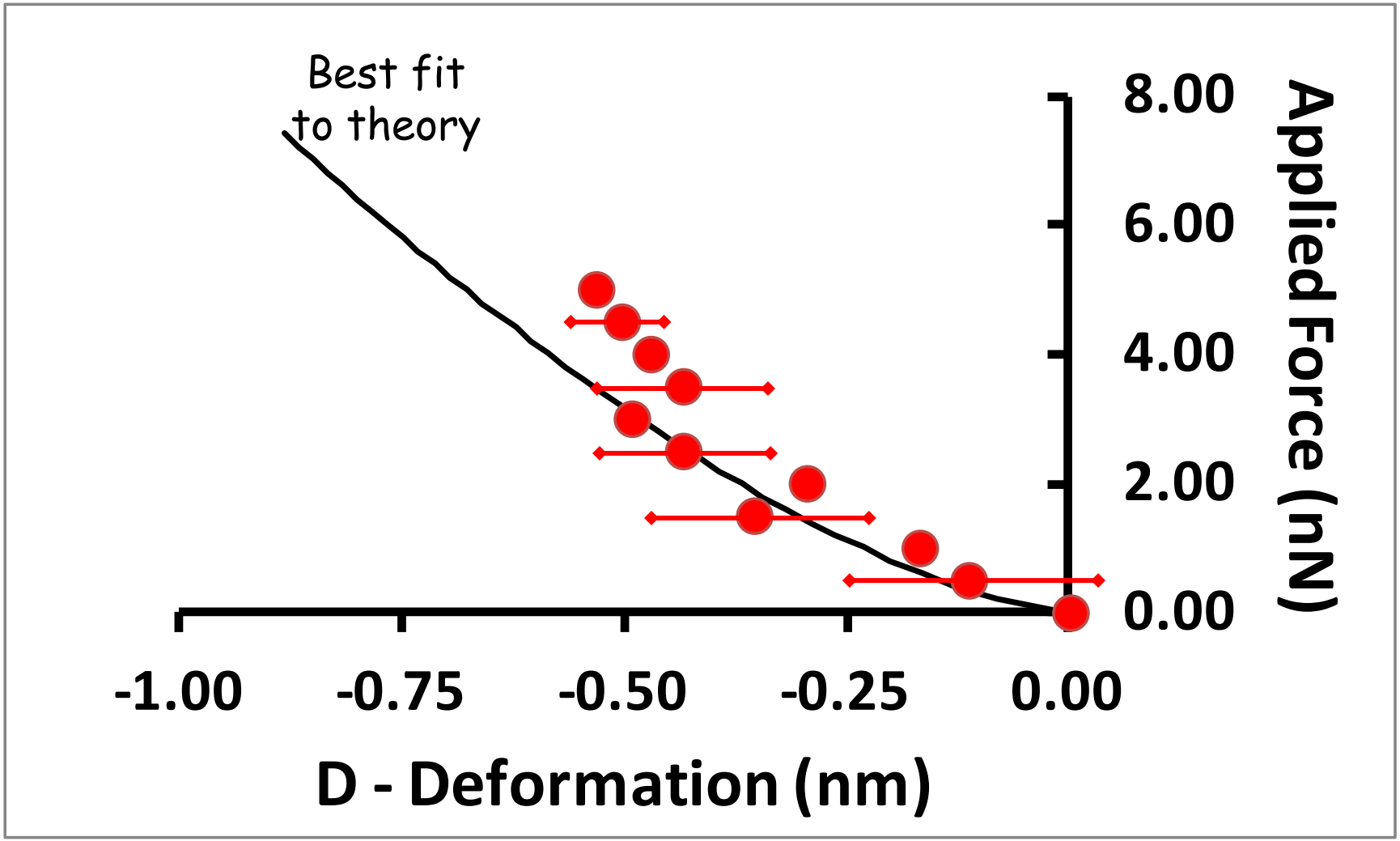
The calibration depends on

- the set-up and alignment of the laser with the cantilever
- the piezo displacement velocity (speed of indentation)
- the amount of cantilever deflection
- any non-linearity in piezo displacement
- piezo-aging

Use same parameters and alignment as when taking the original data.

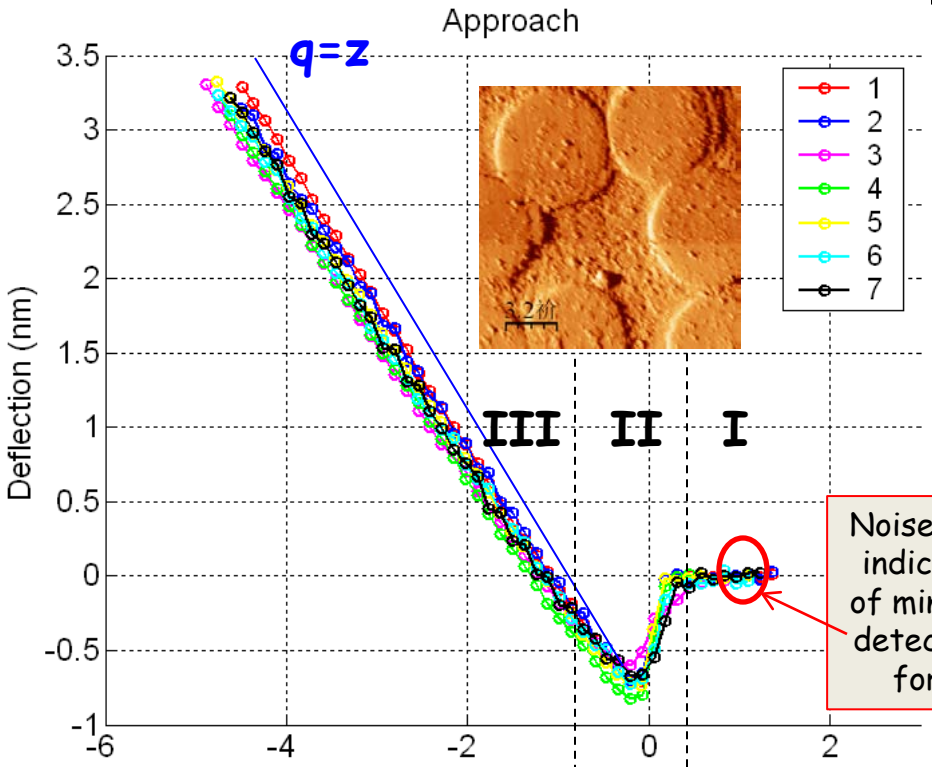

Applied Force vs. Displacement
10.0
5.0
0.0
F (nN)
infinitely hard
sample
1
2
Relaxation - Turn off hardness
D
E*=5 GPa
R=5 nm
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
z(nm)

Errors Can Be Large When Measuring Deformation

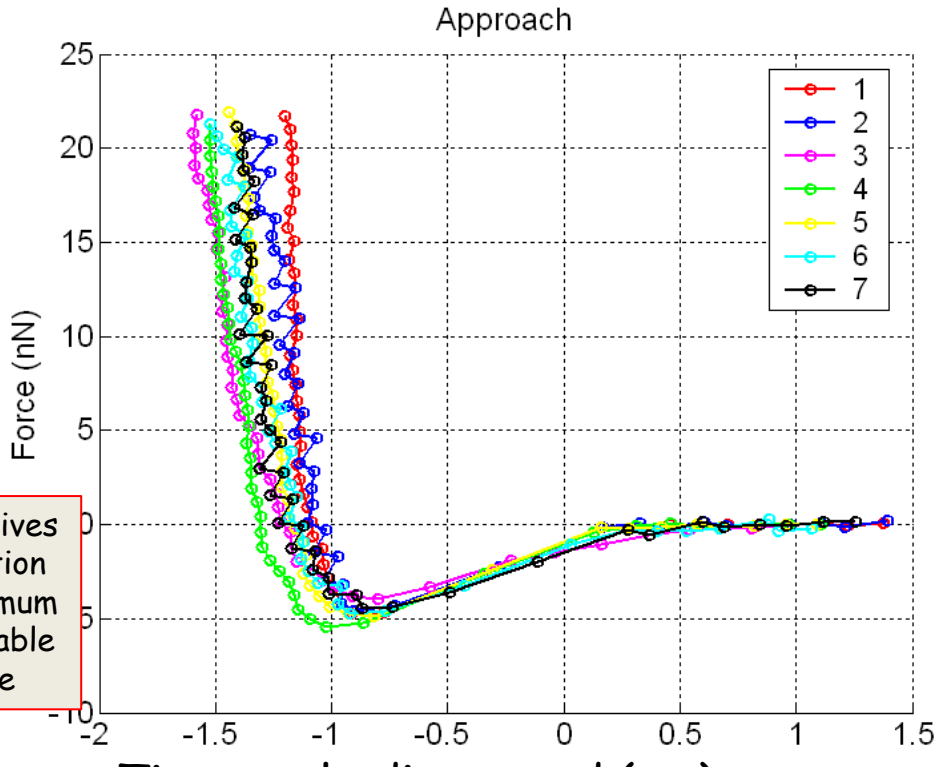


Force spectroscopy – an example

Convert
cantilever deflection vs. z-displacement
to
force vs. separation (gap)



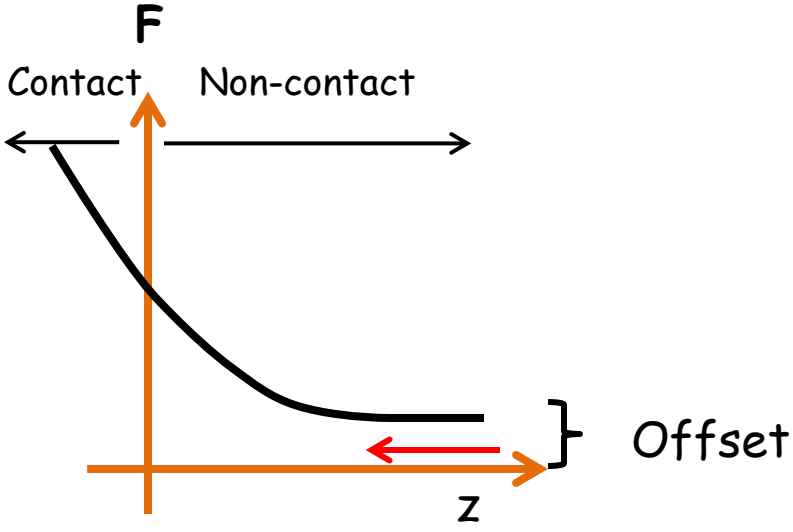
Noise gives indication of minimum detectable force



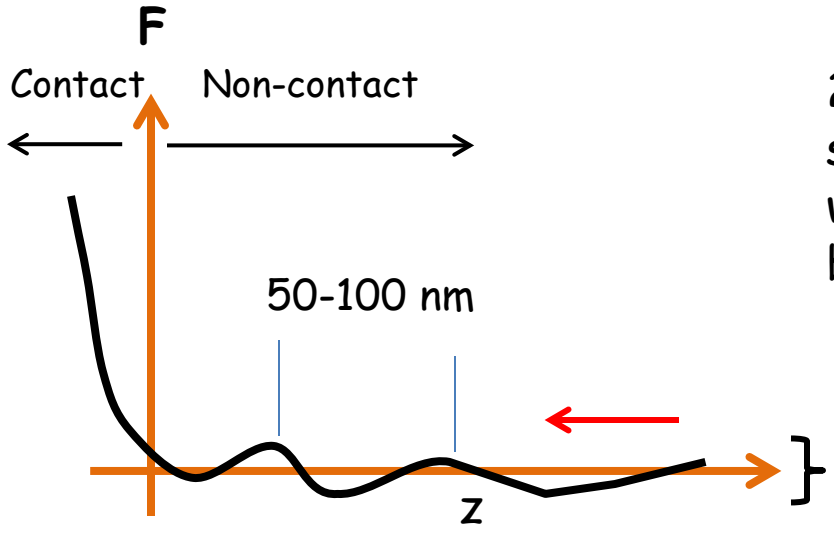
d=z+q

d axis is often re-centered to zero where force is a minimum

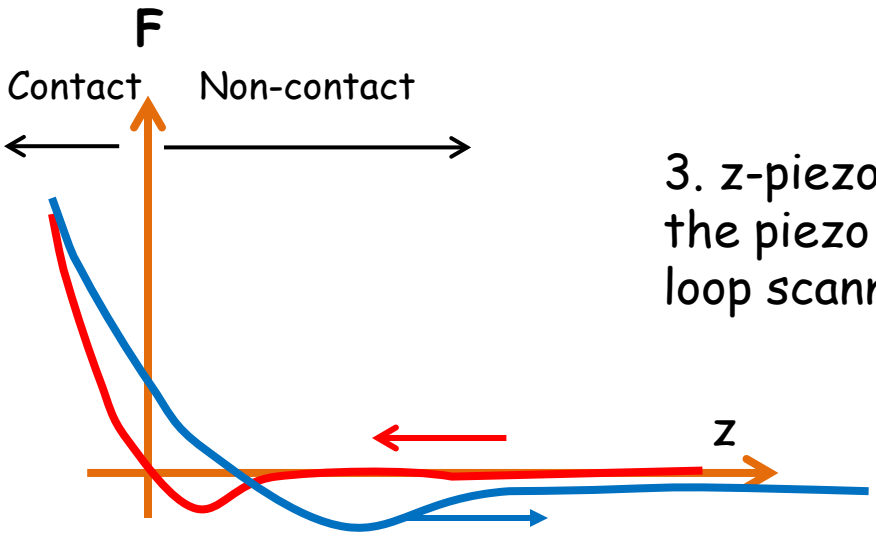
Artifacts when measuring cantilever deflection vs. z-displacement



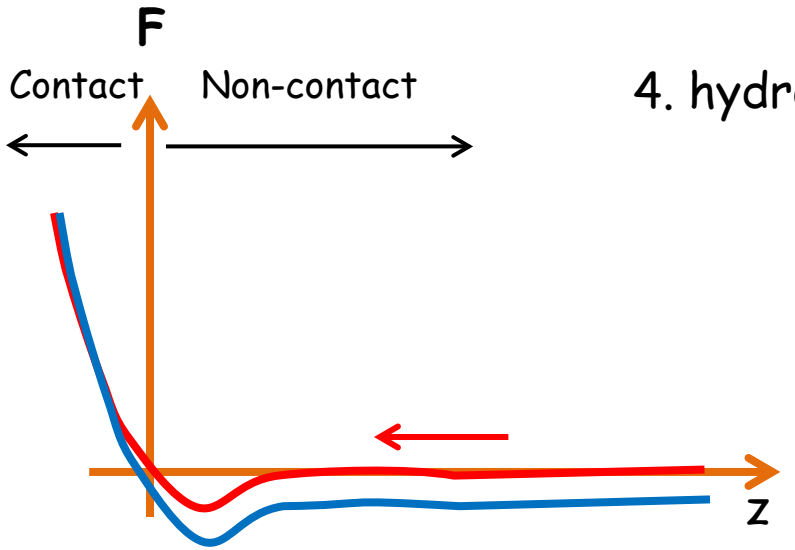
1. Laser spot not centered on photodiode. Re-center to make PSD output zero when far from sample



2. Laser spot reflecting off sample into PSD, interfering with laser light reflected from back side of the cantilever.

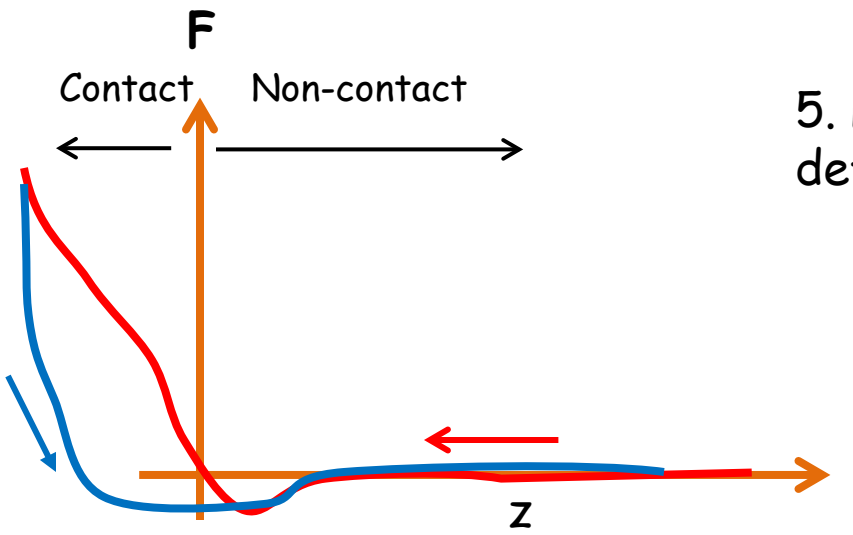


3. z-piezo hysteresis –exercise the piezo or switch to closed loop scanner



4. hydrodynamic drag – reduce speed

Artifacts



5. Large indentation produces plastic deformation – reduce applied force

Simulations: Force-Distance Outputs in VEDA

Observed cantilever deflection vs. z distance

Tip-sample interaction force vs. z distance

Tip-sample gap vs. z distance

Tip-sample interaction force vs. d

Indentation vs. z distance

Up Next: Modulus and Adhesion Maps