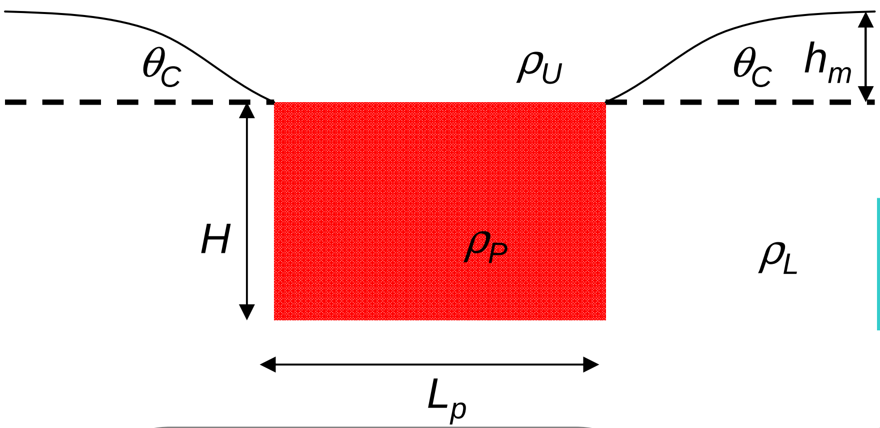
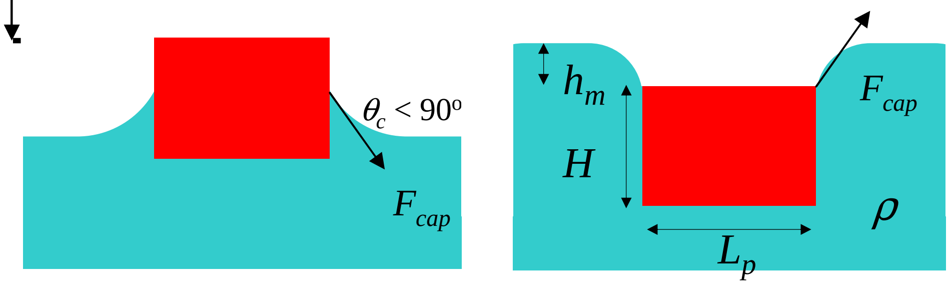
Interfacial Modeling: 1 Particle Case



*Hydrophilic, Dense Particles



Vertical Force Balance

$$F_w = F_b + F_m + F_{cap}$$

$$F_w = Mg/w$$

$$F_b = \rho g H \cdot L_p$$

$$F_m = \rho g h_m \cdot L_p$$

$$F_{cap} = \gamma \sin\theta_C$$

Linearized Meniscus Equation

$$\frac{d^2h}{dx^2} = \frac{\rho g}{\gamma}$$

ρ = fluid density difference

γ= surface tension

Solution

$$h(x) = \frac{-\tan(\theta_c)\, e^{-q(x)}}{q}$$

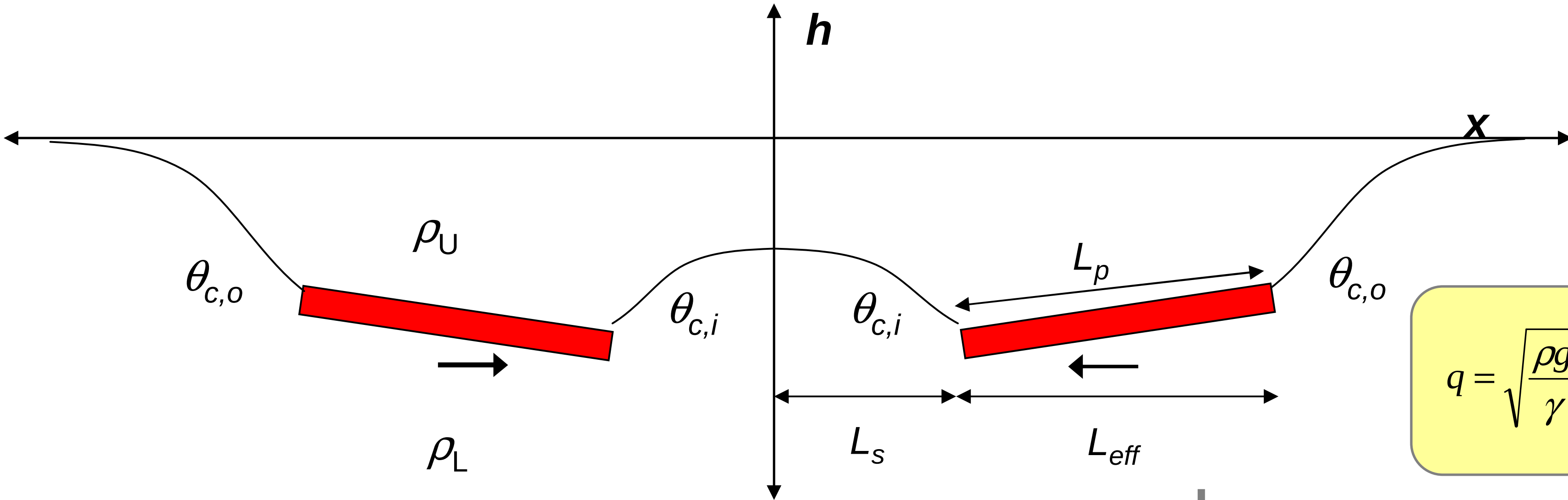
$$q = \sqrt{\frac{\rho g}{\gamma}}$$

Assumptions

-Rectangular particle with inifinite depth

-Contact line pinned at the corner

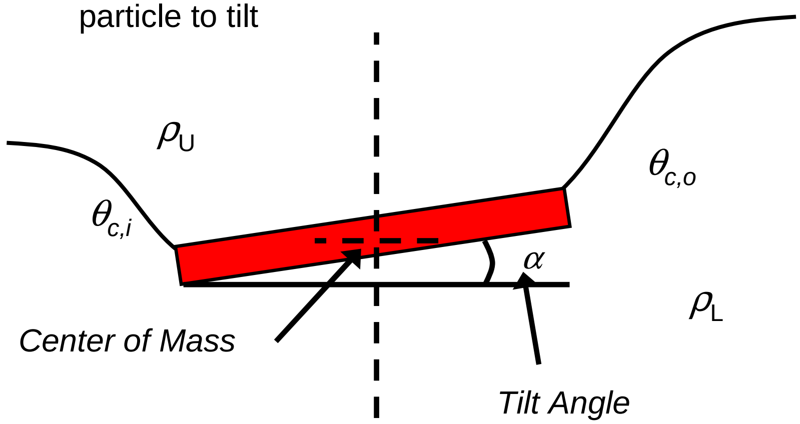
Interfacial Modeling: 2 Particle Case



$$q = \sqrt{\frac{\rho g}{\gamma}}$$

Torque Balance

Change in $\theta_{c,i}$ causes particle to tilt



Inner Region

Boundary Conditions

$$h_i\left(x = L_S\right) = h_{i,p}$$

$$\frac{dh_i}{dx}\left(x = 0\right) = 0$$

Solution

$$h_i\left(x\right) = \frac{h_{i,p}\cosh\left(qx\right)}{\cosh\left(qL_S\right)}$$

Outer Region

Boundary Conditions

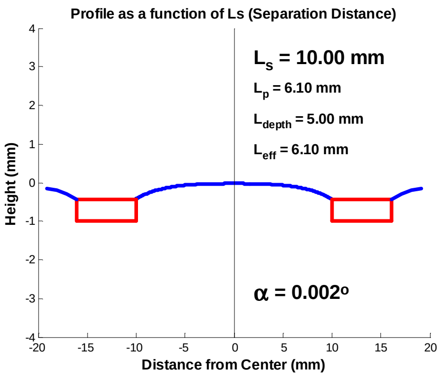
$$h_o\left(x \to \infty\right) = 0$$

$$\frac{dh_o}{dx}\left(x = L_s + L_{eff}\right) = \tan\theta_{c,o}$$

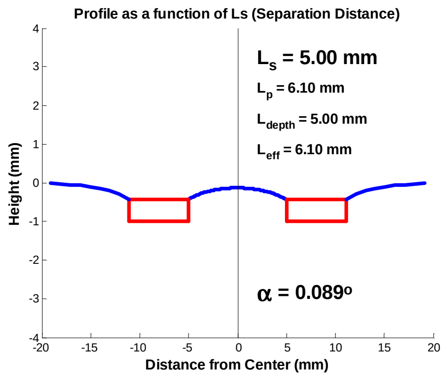
Solution

$$h_o\left(x\right) = \frac{-\tan\left(\theta_{c,o}\right)e^{-q\left(x-\left(L_S + L_{eff}\right)\right)}}{q}$$

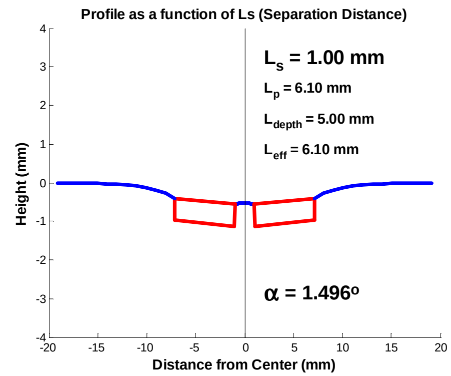
Tilt Modeling



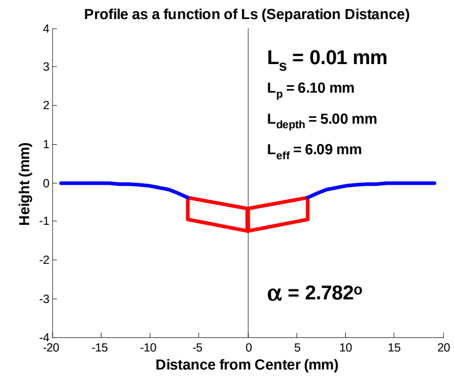
L_s = 10.00 mm
α = 0.002º



L_s = 5.00 mm
α = 0.089º



L_s = 1.00 mm
α = 1.496º



L_s = 0.01 mm
α = 2.782º

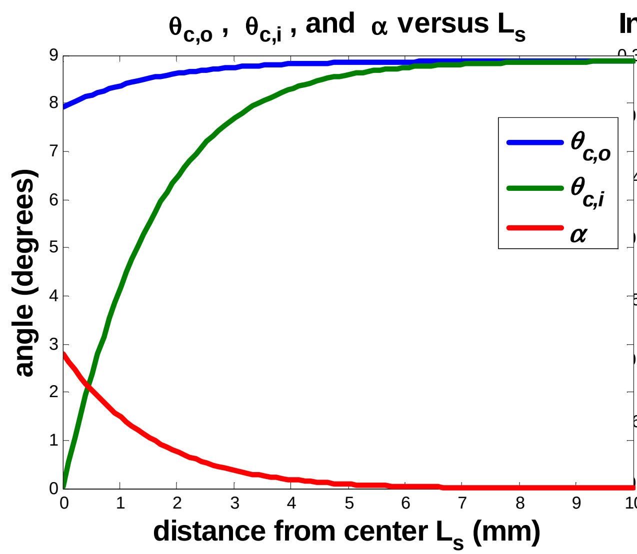
The system of equations was solved using MATLAB

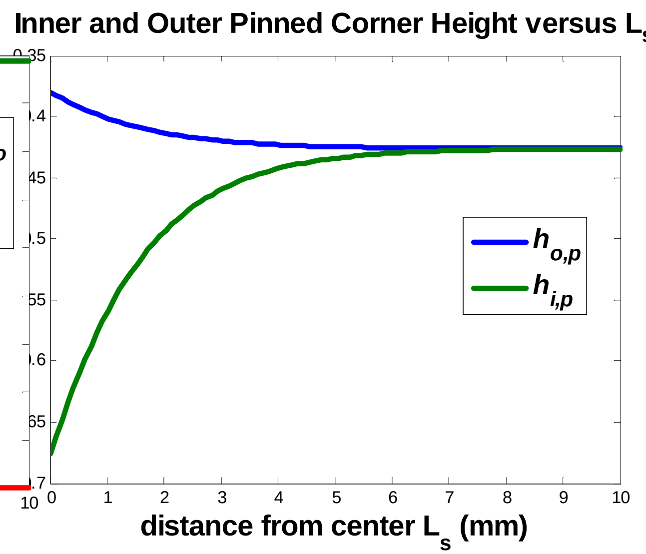
Particles

Particle Density ρ_p : 2,300 Kg/m^3
Lp : 6.10 mm
Ldepth : 5.0 mm

Liquid

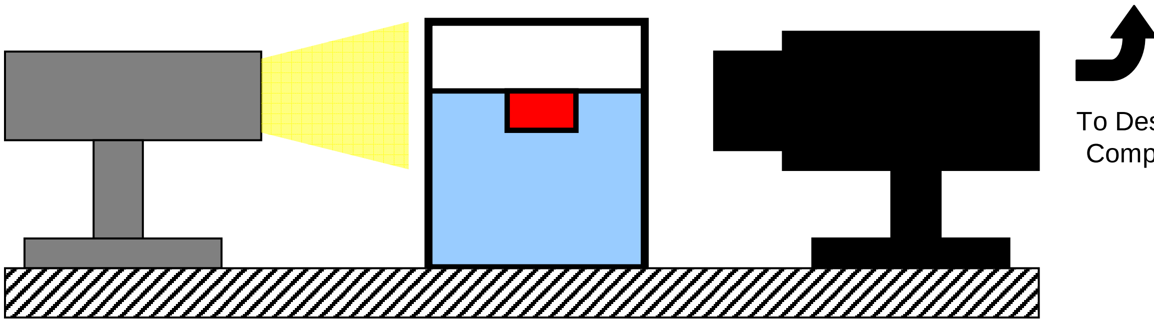
Material : Water
Denisty ρ_p : 1,000 Kg/m^3
Surface Tension γ: 0.073 N/m



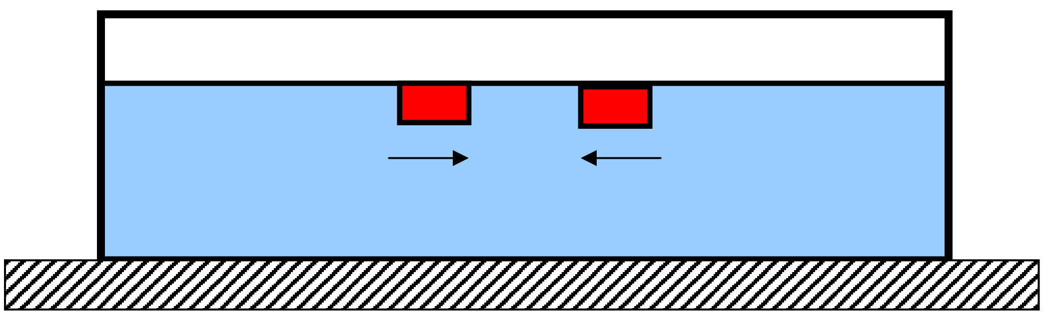


Particle Tilt Measurement

Front View



Camera View

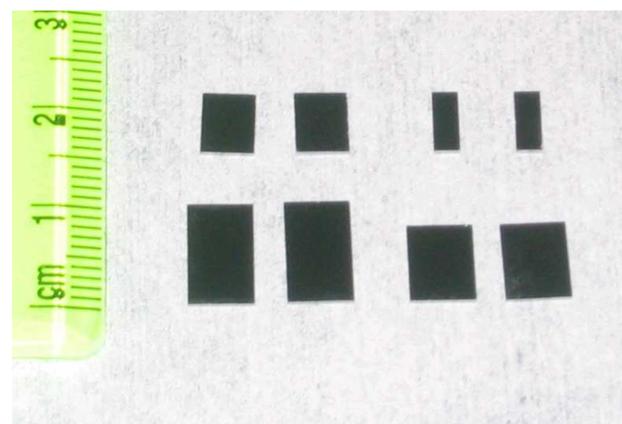


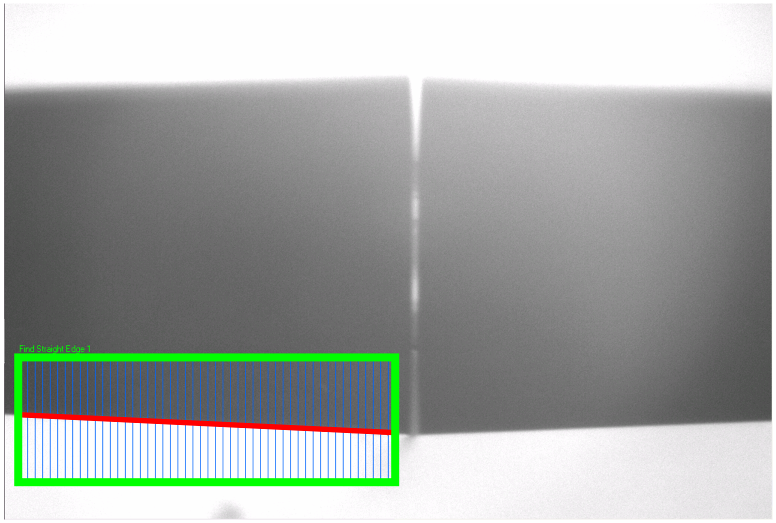
Particles

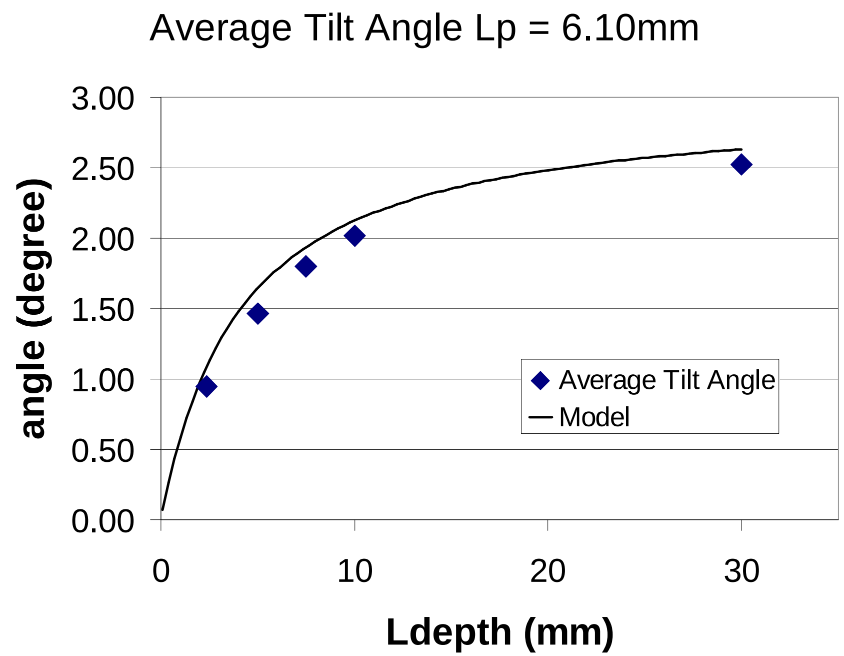
Material : Si
Particle Density ρ_p : 2,300 Kg/m^3
Fixed Dimension : 6.10 mm
Varied Dimension : 2.37 mm to 30.0 mm

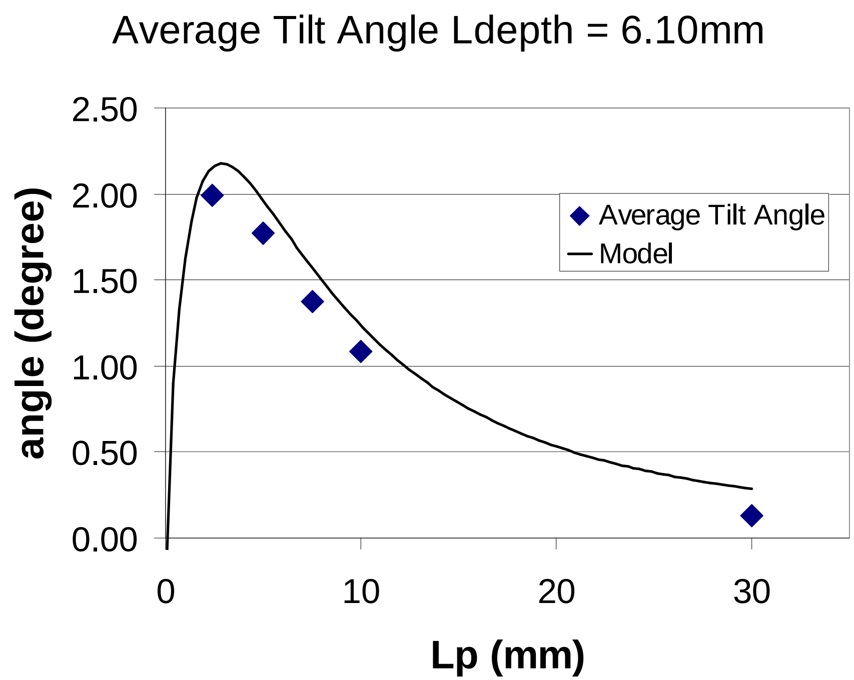
Liquid

Material : Water
Density ρ: 1,000 Kg/m^3
Surface Tension γ: 0.073 N/m





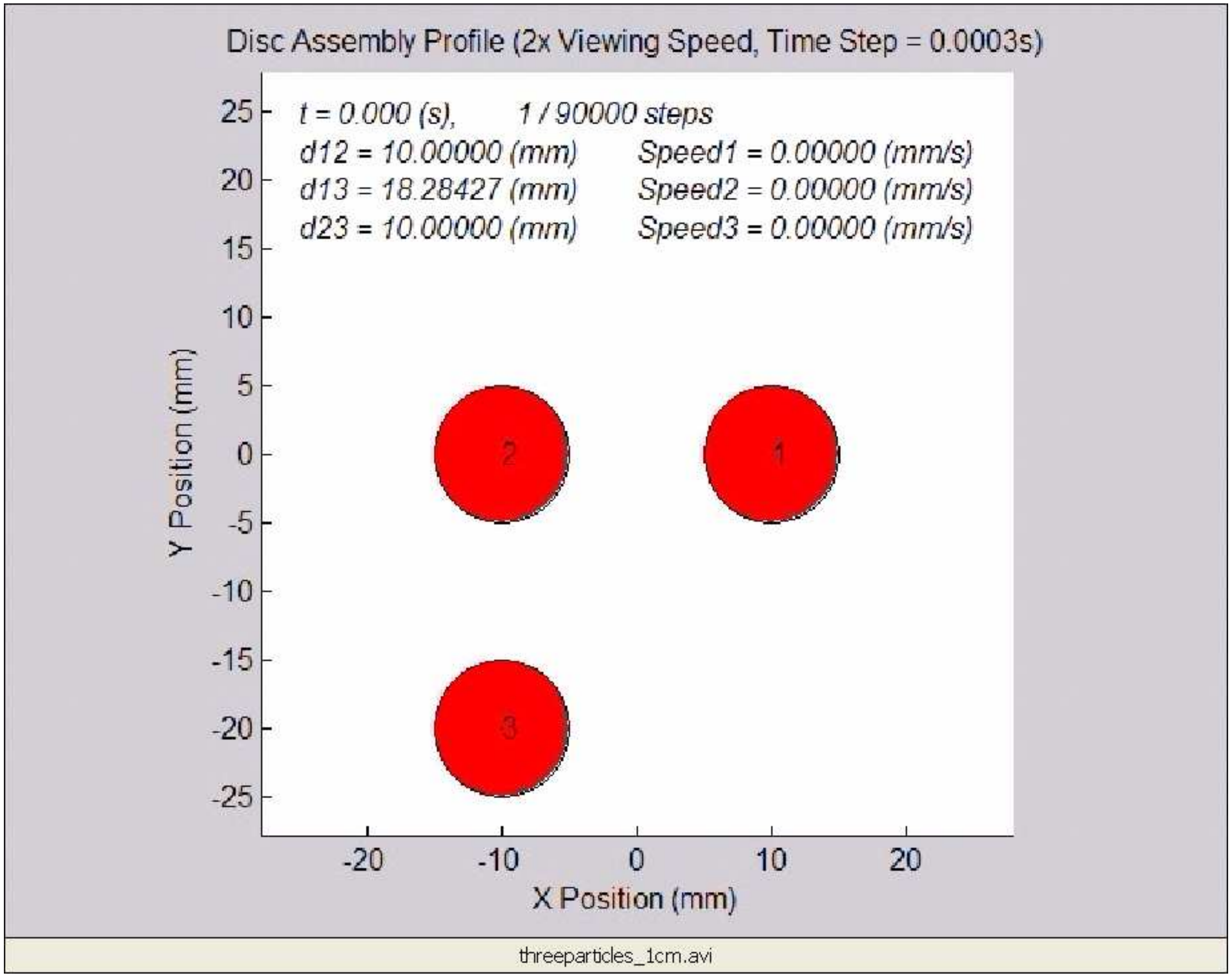




1. Acquire the image after the particles have assembled and reached equilibrium position

2. Post process with NI Vision Assistant Software to obtain the tilt angle α

Rigid Body Dynamics Simulation



Summary

- Established low cost way of assembling biosensor arrays
- Showed possibility of directed self-assembly could be accomplished by controlling repulsive and binding forces
- Developed a model to describe the flotation of one object that are denser than the fluid
- Extended the model to describing the self-assembly of two objects
- Verified models with tilt experiment
- Results were used in a rigid body dynamics simulation to predict the final configuration of multiple objects