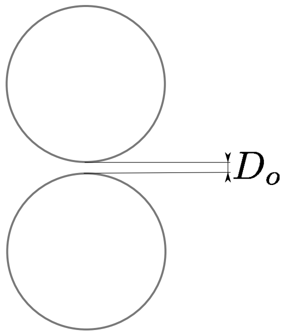
Chapter 5: Adhesion

Exercise 1

Two identical spherical copper particles are placed, as the figure shows. The distance between the particles is $D_o = 0.4$ nm.



What is the maximum allowed particle diameter, so that the lowest particle is held by the attraction forces (against gravity)? Copper density is 8960 kg/m^3.

Solution:
$d = 0.624$ mm

Exercise 2

Repeat the previous exercise by assuming that the upper particle is a wall (you can state that this is a particle of an infinite size and mass).

Solution:
$d = 0.882$ mm

Exercise 3

In this exercise, we use JKR-theory to describe two identical stationary particles in contact. The particle diameter is 200 μm (these may be sand particles). Effective Young's modulus, E_*, is equal to 70 GPa.

(1) We first assume that the particles are not adhesive. They are pressed towards each other with a force of 20 N. How much do the particles deform due to this force? What is the pressure distribution within the contact area?

(2) Next, we assume that the particles are adhesive and surface energy (per surface) is $\gamma = 5.0$ J/m^2. Calculate how much the particles deform then and compare the results with the case with no adhesion.

(3) Finally, we will separate the particles. What is the force that is necessary to pull them apart? What is the height of the 'neck' that forms just before the rupture?

Solution:
(1) $\delta = 9.724$ μm;
(2) $\delta = 9.745$ μm;
(3) $P_{sep} = 2.356 \cdot 10^{-6}$ N; $\delta_{sep} = 7.79$ nm

Exercise 4

Please solve Example 5.3.2 in the book by writing a computer code to plot the functions described in the example.