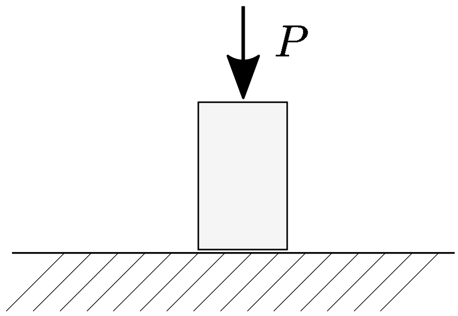
Chapter 3: Introduction to Contact and Impact Mechanics

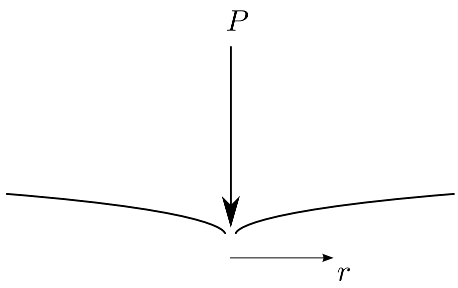
Exercise 1

a) A large surface is made of steel with $E = 200{\cdot}10^9$ Pa, and $\nu = 0.3$.

A solid circular punch with a radius of 20 mm applies a force of 10 000 N on the surface. How much will the surface deform?



b) Next, we replace the punch with a single force (also 10000 N). Calculate the surface deformation at a distance of $r = 2$ cm from the force location



Solution:
(a) $\bar{u}_z = 1.138\ \mu$m; (b) $\bar{u}_z(r = 2\text{ cm}) = 0.724\ \mu$m.

Exercise 2

Two quartz spherical particles move in a multiphase flow. During the flow, they collide along the normal to the plane of impact. We can estimate that the relative velocity before the collision is 0.02 m/s.

The particles have different sizes, where the first particle has a diameter of 100 μm, and the second particle has a diameter of 150 μm.

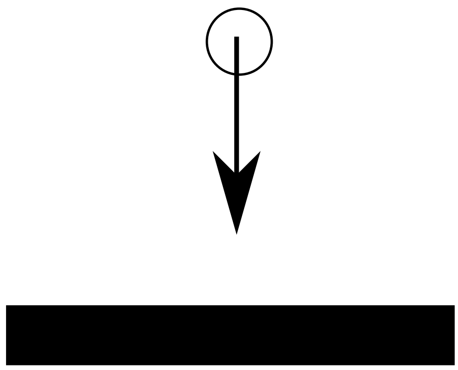
We know that $E = 75{\cdot}10^9$ Pa, $\nu = 0.19$, and the particle material density is 2850 kg/m^3. These properties are the same for both particles.

What is the collision duration assuming that the collision is elastic and Hertz theory can be applied?

Solution: $t_c = 7.748{\cdot}10^{-7}$ s

Exercise 3

A particle collides vertically with a "floor". The particle has a radius of 1 mm. The velocity of the particle is 0.02 m/s.



The material properties for both the particle and wall are: Young's modulus is $80{\cdot}10^9$ Pa, Poisson coefficient is 0.20, and the particle material density is 3000 kg/m^3.

What is the maximum indentation/deformation, contact radius, force and pressure?

We assume that Hertz theory can be used.

Solution: $\delta_c = 1.05{\cdot}10^{-7}$ m, $a_c = 1.025{\cdot}10^{-5}$ m, $P_c = 0.06$ N, $p_{o,max} = 90.89{\cdot}10^6$ Pa

Exercise 4

Look at the section on the "linear-spring and dashpot model": specifically the examples presented there.

Repeat the analysis by plotting the functions using any software you prefer. Note how the functions behave outside the studied time span. You can focus on one case, for example, when $\beta_n = 0.3$.

Finally, plot a similar graph for the case where there is no damping in the system, i.e., only the elastic force acting on the particles.