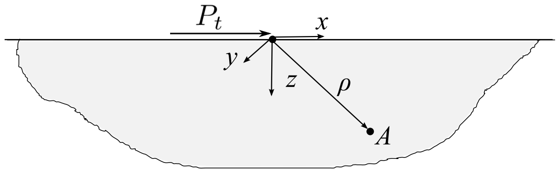
Chapter 4: Tangential contact

Exercise 1

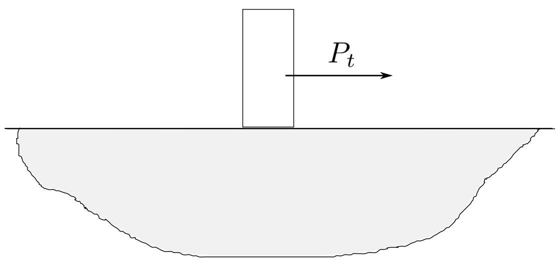
A force that is tangent to the surface and has a magnitude of 20 kN is applied to a large half-space composed of aluminium. The material has a Young's modulus of $70{\cdot}10^9$ Pa and a Poisson's ratio of 0.33.



Using any software of your choice, create plots of the deformations (i.e., u_x, u_y, and u_z) of the *surface* of the half-space at $z = 0$, and analyze the results. Make the plots along x-axis, that is, you can state that y is also equal to 0.

Exercise 2

A large half-space made of aluminium with a Young's modulus of $70{\cdot}10^9$ Pa and a Poisson's ratio of 0.33 is in contact with a solid cylinder that has a radius of 20 cm. Let us make the assumption that the cylinder is completely rigid and has no deformation, or that its Young's modulus is infinitely large.



What is the shear stress distribution likely to occur at the contact surfaces when a tangential force of 200 000 N is applied to the cylinder? Additionally, what is the magnitude of the tangential indentation in this scenario?

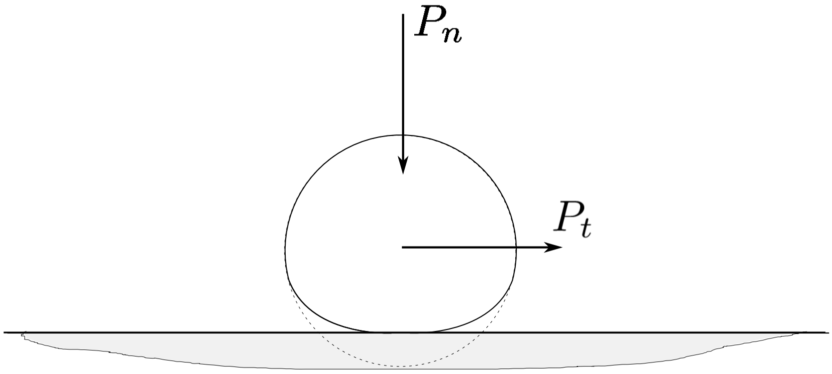
Solution:

$\delta_t = 7.93\ \mu\text{m}$

Exercise 3

A rubber ball of radius 5.0 cm is pressed against a hard surface with a vertical/normal force 100 N. For rubber, $E = 10^9$ Pa, and $\nu = 0.5$.

(a) As a result of the vertical force, what is the radius of the contact area while the ball undergoes flattening?



(b) Subsequently, a tangential force P_t is applied. What is the maximum allowable magnitude of the force (let's call it $P_{t,max}$) to prevent the ball from sliding, given that the coefficient of friction is 0.2?

(c) Let us allow now the tangential force to vary from 0 to $P_{t,max}$. Show a relation for the radius of the external "ring" with the partial slip as a function of the varying force P_t. Sketch the obtained function.

Find a similar relation for the tangential indentation and sketch it. What is the maximum possible tangential indentation?

Solution:

(a) $a = 1.412$ mm; (b) $P_t^{max} = 20$ N; (c) $\delta_t^{max} = 11.963\ \mu\text{m}$