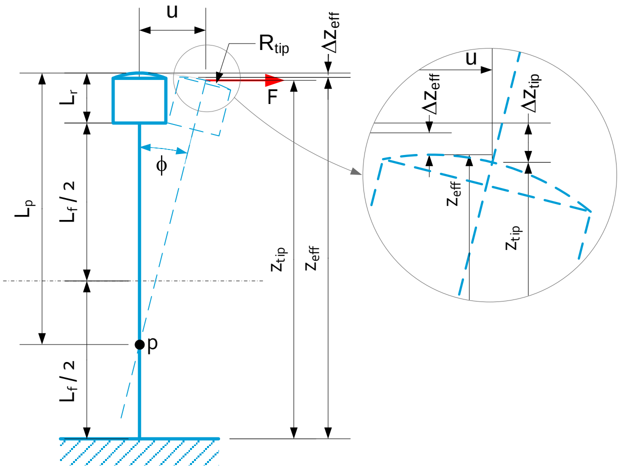
**Introduction**

Typically struts and leaf springs demonstrate a parasitic sag-movement when moving sideways.

In some cases this parasitic motion is unwanted. Then a rigid tip can be implemented on the elastic element. By designing the proper tip radius, the parasitic motion can be perfectly compensated resulting in a straight-line guided motion.




*Kinematic behavior*

**Formulas**

The kinematic behavior is described by the following formulas for small values of u, $\phi$:

$$z_{tip} = (L_r + L_f) - \frac{2}{15} \cdot \frac{2L_f^3 + 20L_r^2 L_f + 10L_r L_f^2 + 15L_r^3}{(2L_r + L_f)^2} \cdot \phi^2$$

$$\Delta z_{tip} = -\frac{2}{15} \cdot \frac{2L_f^3 + 20L_r^2 L_f + 10L_r L_f^2 + 15L_r^3}{(2L_r + L_f)^2} \cdot \phi^2$$

$$u_{tip} = \frac{2}{3} \cdot \frac{3L_r L_f + L_f^2 + 3L_r^2}{2L_r + L_f} \cdot \phi$$

$$L_p = \frac{u_{tip}}{\tan\phi} \approx \frac{u_{tip}}{\phi} = \frac{2}{3} \cdot \frac{3L_r L_f + L_f^2 + 3L_r^2}{2L_r + L_f}$$

$$z_{eff} = (L_r + L_f) + \left[\frac{R_{tip}}{2} - \frac{2}{15} \cdot \frac{2L_f^3 + 20L_r^2 L_f + 10L_r L_f^2 + 15L_r^3}{(2L_r + L_f)^2}\right] \cdot \phi^2$$

$$\Delta z_{eff} = \left[\frac{R_{tip}}{2} - \frac{2}{15} \cdot \frac{2L_f^3 + 20L_r^2 L_f + 10L_r L_f^2 + 15L_r^3}{(2L_r + L_f)^2}\right] \cdot \phi^2$$

Special case 1: $L_r = 0$ (cantilevered leaf spring / strut)

$$L_p = \frac{2}{3} \cdot L_f$$

$$\left.\begin{aligned} \Delta z_{tip} &= -\frac{4}{15} L_f \cdot \phi^2 \\ u_{tip} &= \frac{2}{3} L_f \cdot \phi \end{aligned}\right\} \Delta z_{tip} = -\frac{3}{5} \frac{u_{tip}^2}{L_f}$$

Special case 2: $\Delta z_{eff} = 0$

$$R_{tip} = \frac{4}{15} \cdot \frac{2L_f^3 + 20L_r^2 L_f + 10L_r L_f^2 + 15L_r^3}{(2L_r + L_f)^2}$$