

For a mass M at the end of the beam (tube) the following expression holds for the lowest axial resonance frequency [6]

$$f_{\text{stretch},1} = \frac{\lambda_1}{2\pi L} \sqrt{\frac{E}{\rho}}, \quad (3.18)$$

with λ_1 given by the smallest positive solution of the equation $\lambda_1 \tan \lambda_1 = \rho AL/M$ and A being the cross sectional (material-containing) area of the beam (tube).