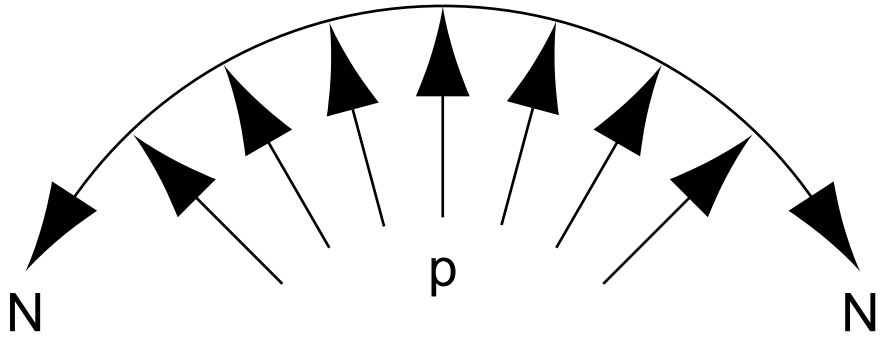
Structural Mechanics of Lobed Inflatable Structures

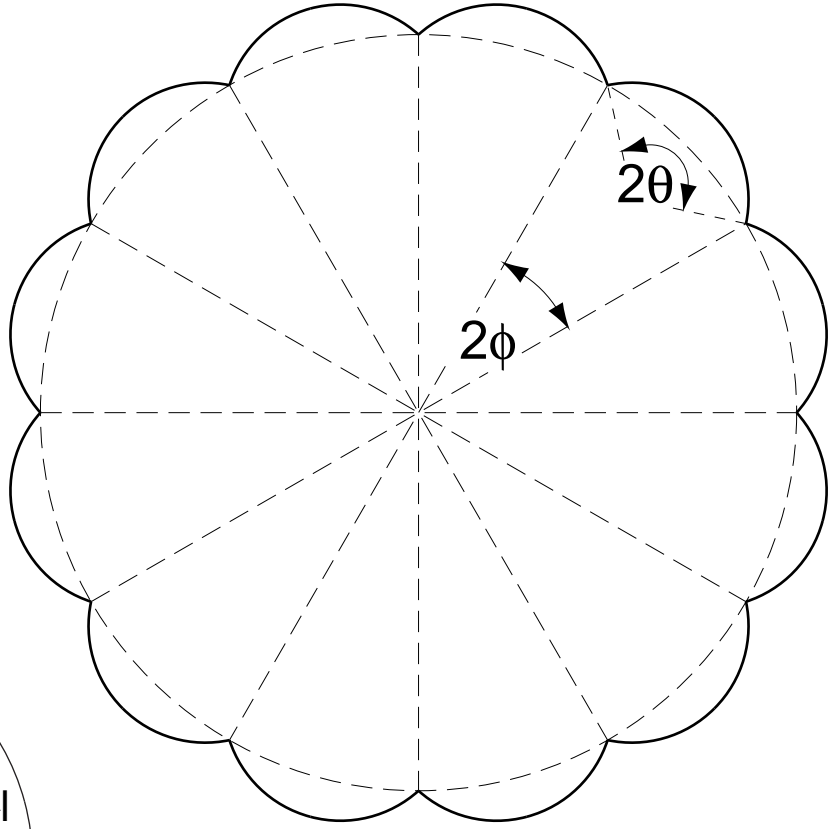
Andrew Lennon† and Sergio Pellegrino‡

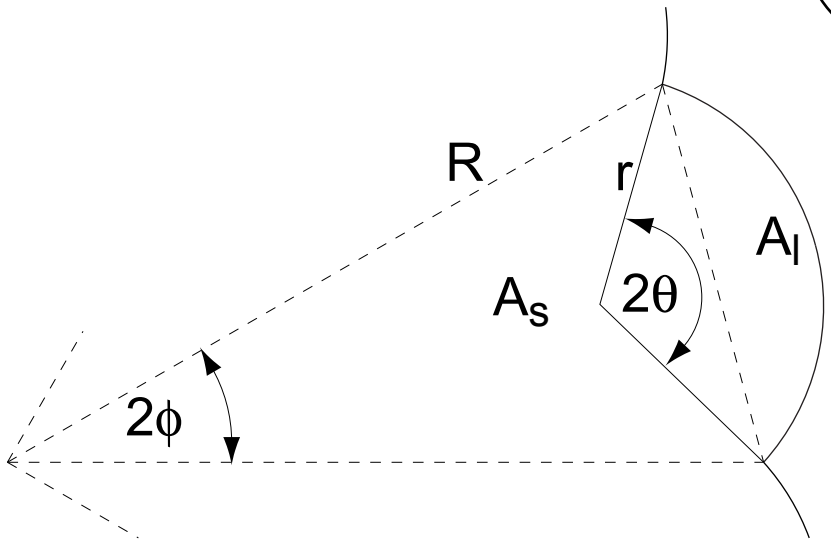
† Consulting Engineer, formerly Cambridge University Engineering Department
‡ Professor, Cambridge University Engineering Department

Examples of Membrane Structures

Equilibrium of Two-Dimensional Lobed Structures

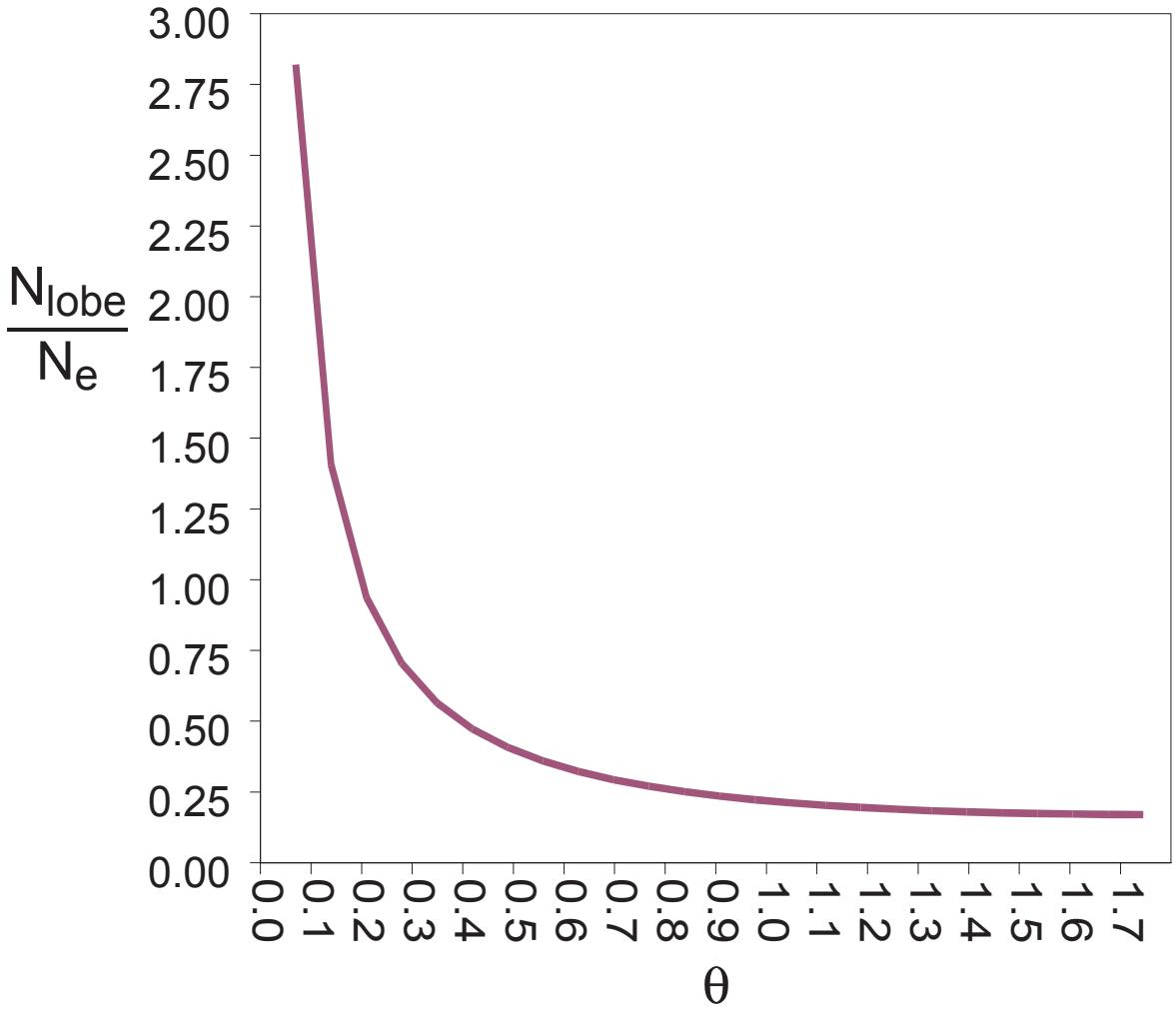






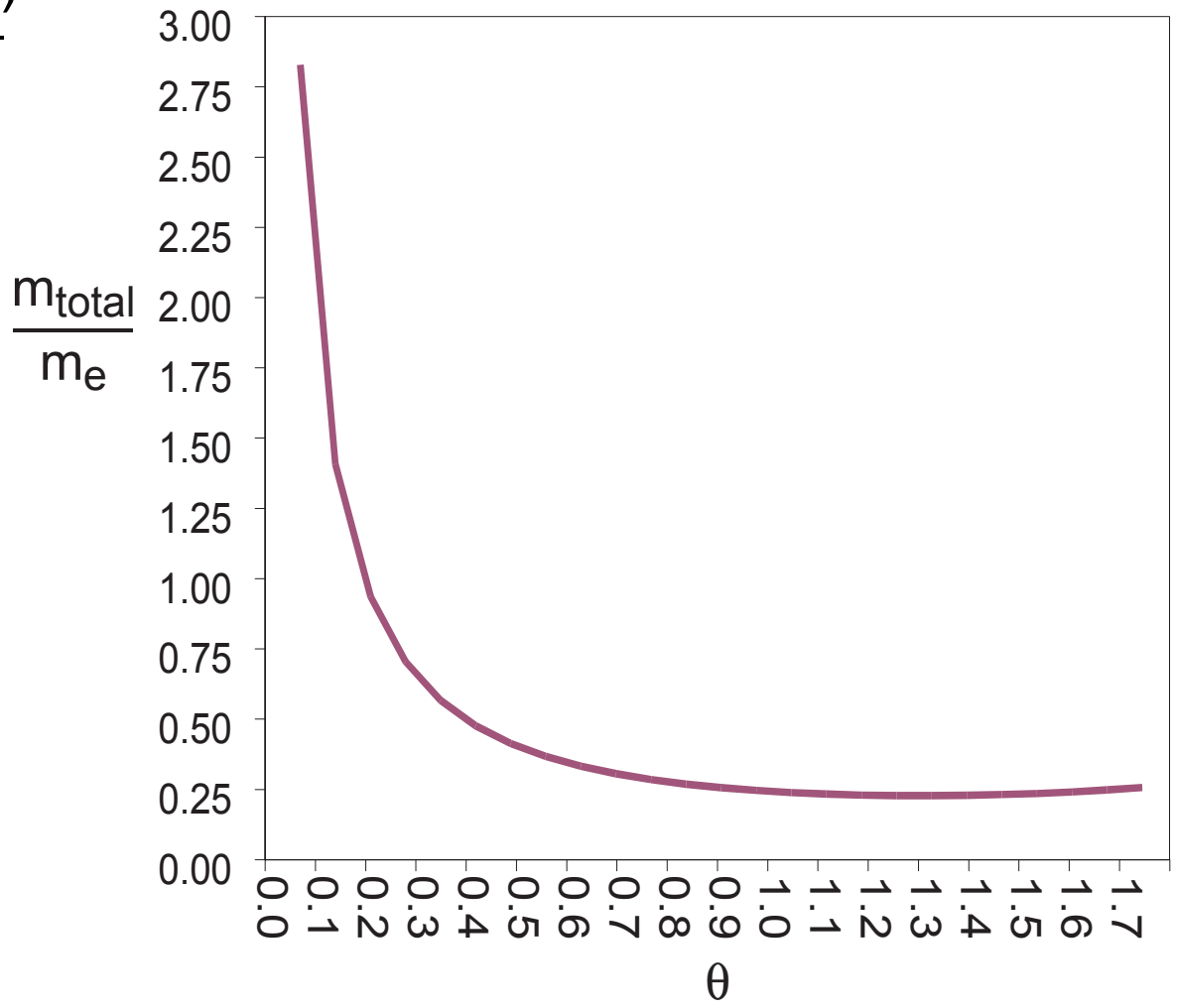
Tension in a Lobed Circular Structure

$$\frac{N_{lobe}}{N_e} = \frac{r}{R_e}$$

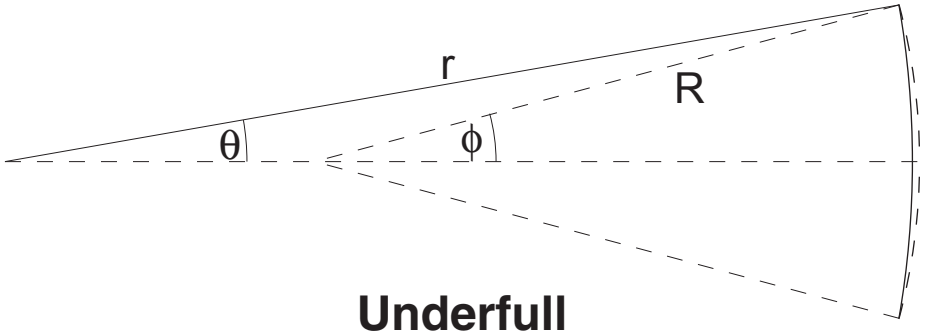


Mass Comparison for a Lobed Circular Structure

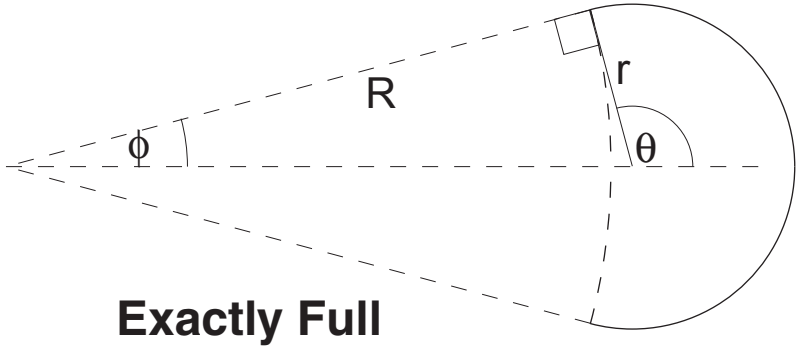
$$\frac{m_{lobed}}{m_{circle}} = \frac{n\theta}{\pi} \frac{R^2}{R_e^{\,2}} \frac{\sin^2(\pi/n)}{\sin^2\theta}$$



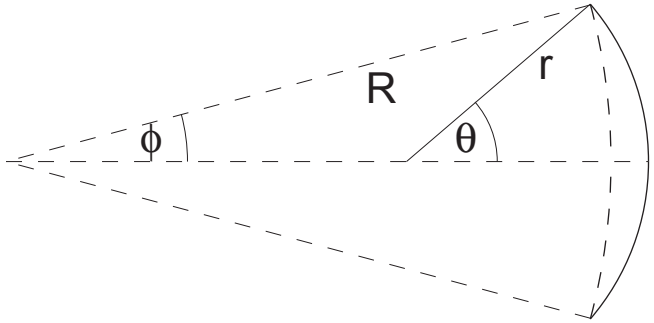
Lobe Fullness



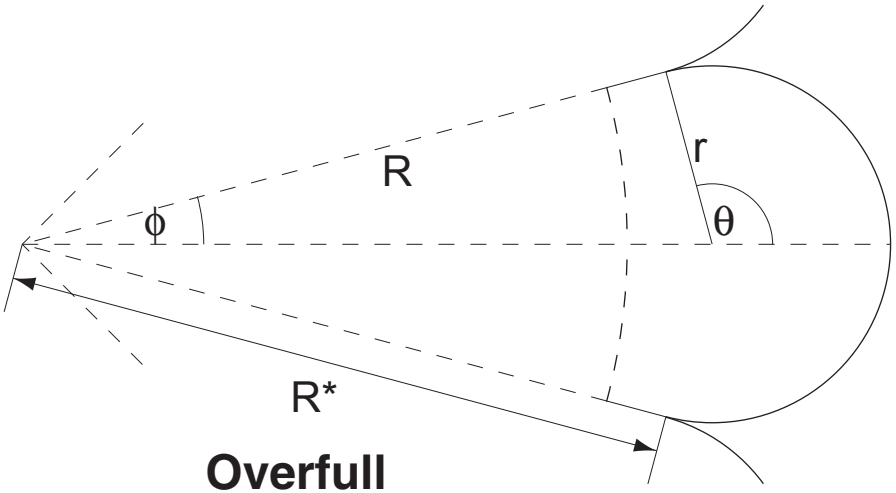
Underfull



Exactly Full

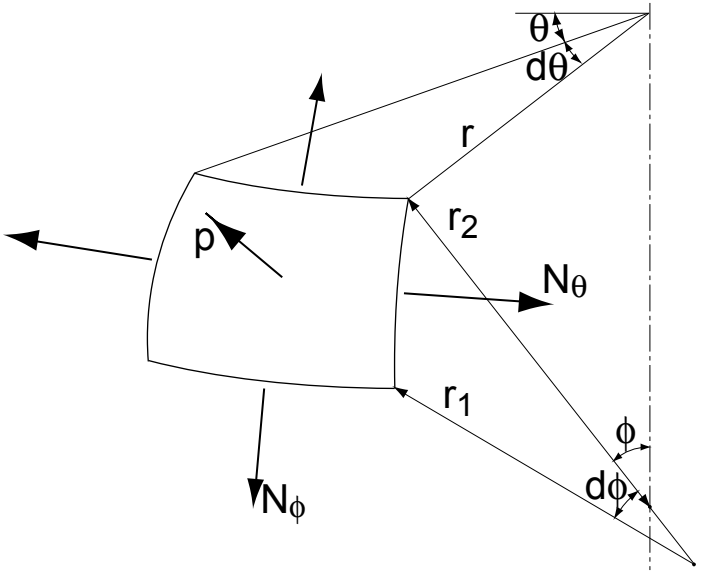


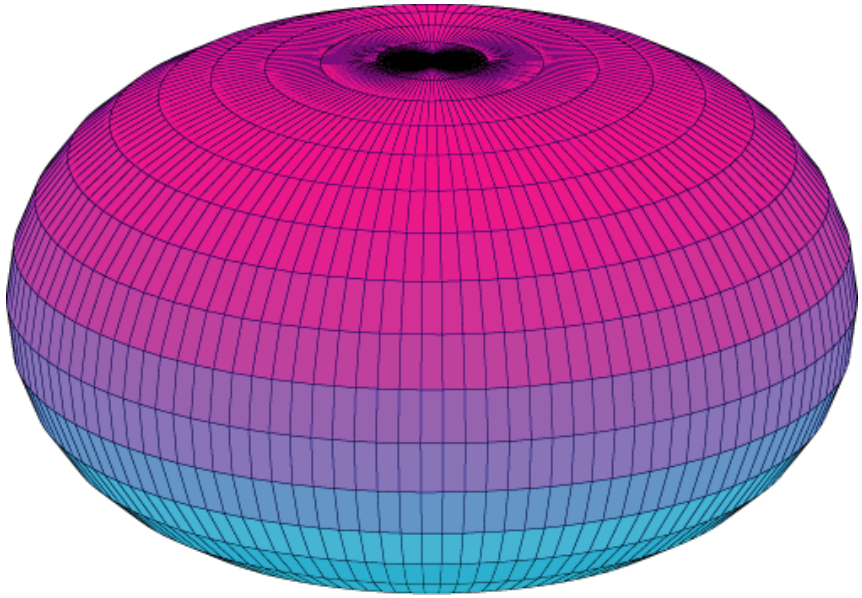
Partially Full

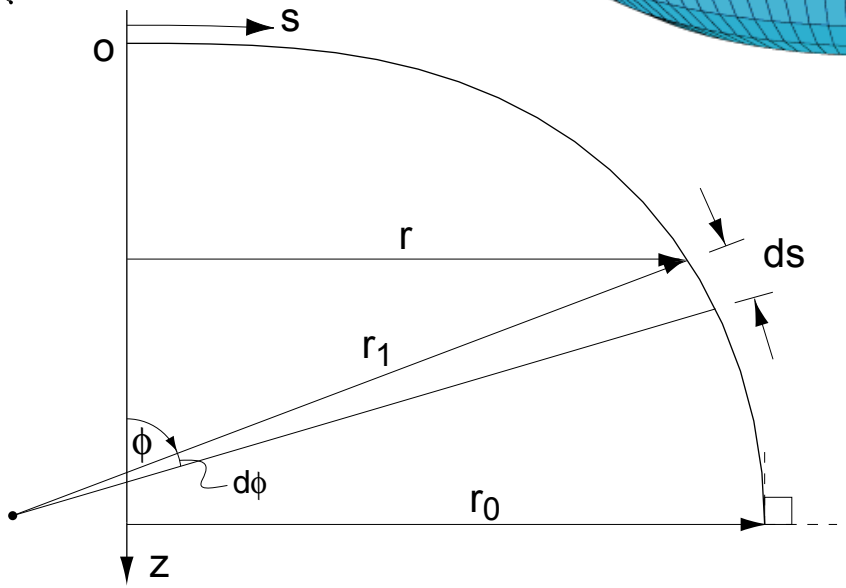


Overfull

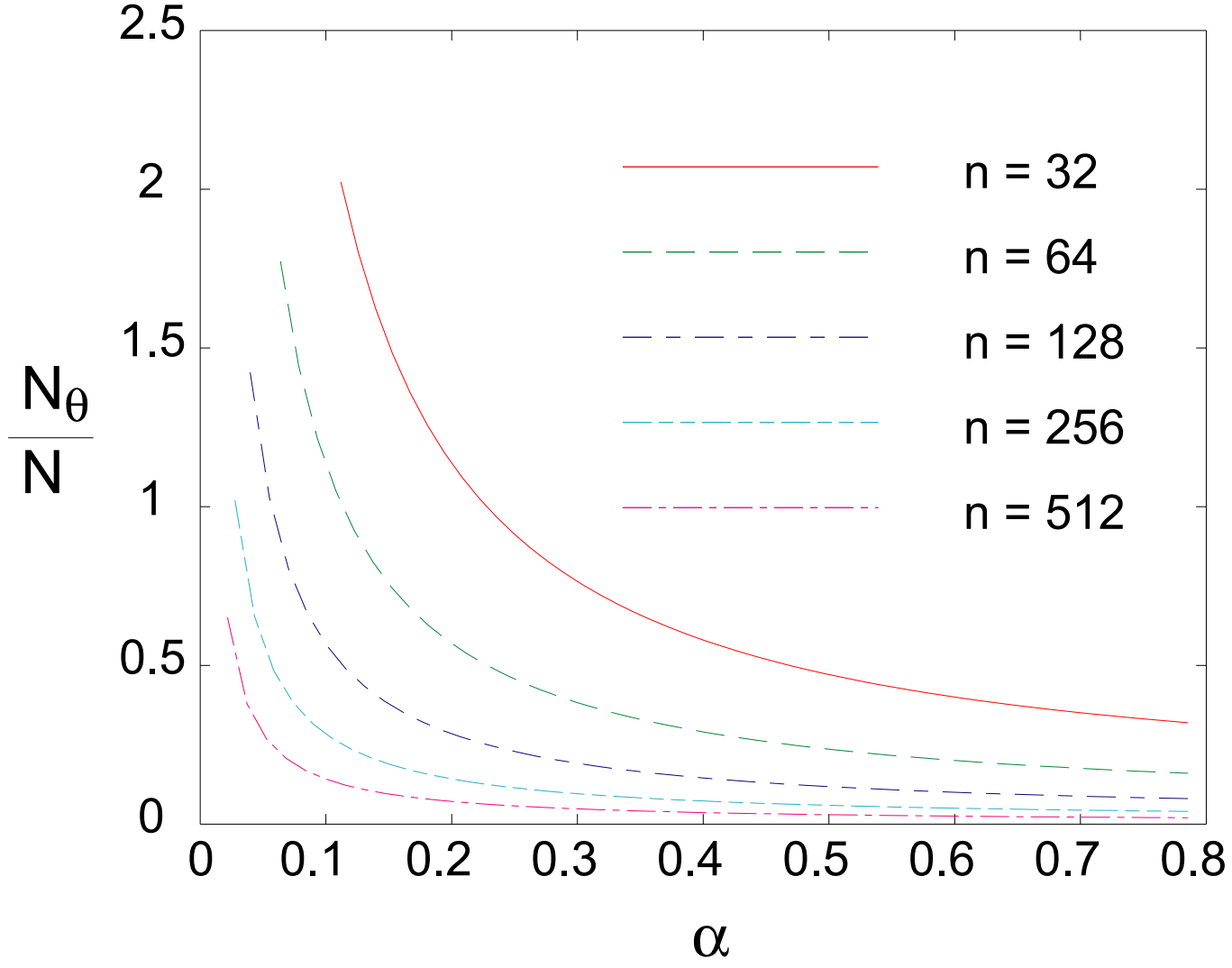
Three-Dimensional Membrane Surfaces



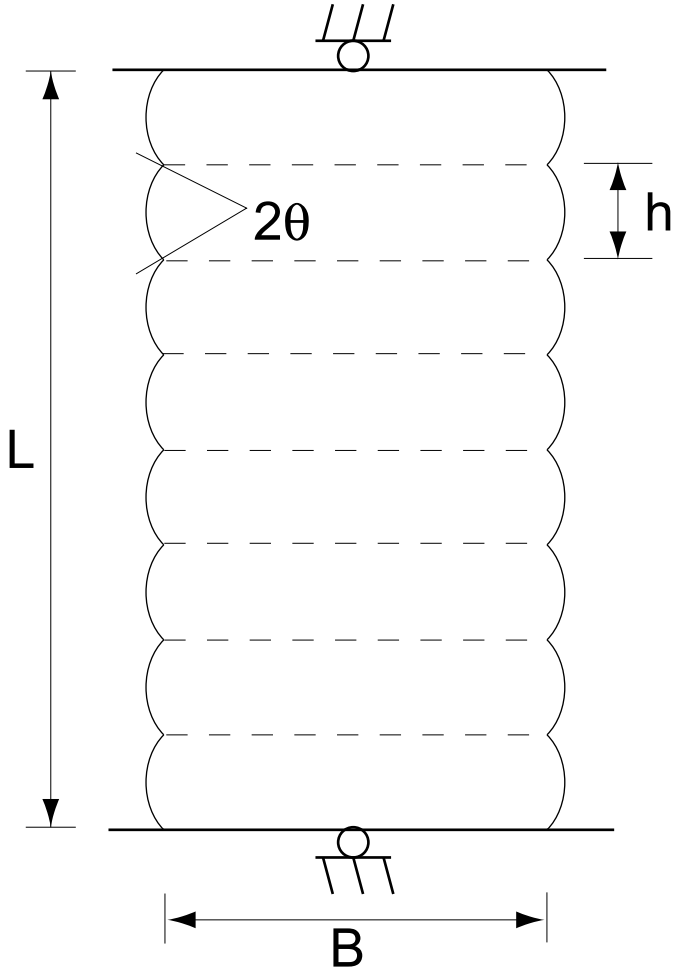


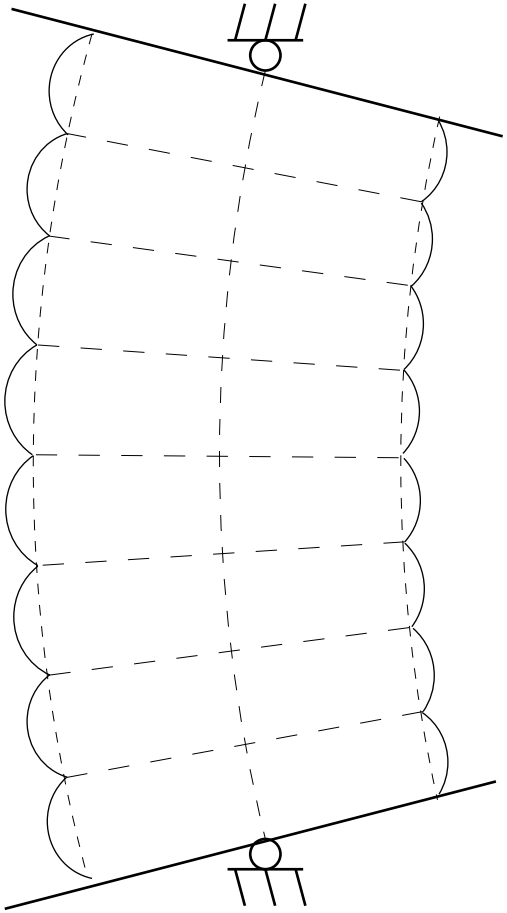


Comparison of Stresses in Three-Dimensional Membrane Surfaces



Stability of Lobed Column





Stability of Lobed Column

$$6\,\frac{Bh}{L^2} \;\geq\; \frac{1}{A_l''}$$

where $$A_l'' = \frac{1}{2}\,\frac{\cos\theta + \theta\,\sin\theta}{\sin\theta - \theta\,\cos\theta}$$

or $$\frac{\pi^2}{2}\,\frac{Bh}{L^2} \;\geq\; \frac{1}{A_l''}$$

Conclusions

lobes reduce tension

lower amount of material to carry the same stress

need to be careful of lobe fullness (excess material)

isotensoid: load in only one-direction

instability can be a problem for lobed structures