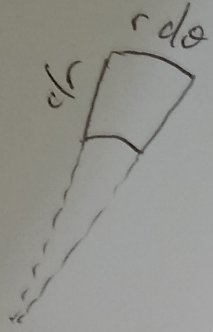
ENERGIA POTENCIAL DE LA MEMBRANA CIRCULAR



$$dE_p = |\vec{T}|\, r\,d\theta\,(ds_r - dr) + |\vec{T}|\, dr\,(ds_\theta - r\,d\theta)$$

$$ds_r = \left((dr)^2 + (dz)^2\right)^{1/2} = dr\left(1 + \left(\frac{dz}{dr}\right)^2\right)^{1/2} \simeq dr\left(1 + \frac{1}{2}\left(\frac{dz}{dr}\right)^2\right)$$

$$\Rightarrow ds_r - dr \simeq \frac{1}{2}\left(\frac{\partial z}{\partial r}\right)^2 dr$$

$$ds_\theta = \left((r\,d\theta)^2 + (dz)^2\right)^{1/2} = r\,d\theta\left(1 + \left(\frac{dz}{r\,d\theta}\right)^2\right)^{1/2} \simeq r\,d\theta\left(1 + \frac{1}{2}\left(\frac{dz}{r\,d\theta}\right)^2\right)$$

$$\Rightarrow ds_\theta - r\,d\theta \simeq \frac{1}{2}\,\frac{1}{r^2}\left(\frac{\partial z}{\partial \theta}\right)^2 r\,d\theta$$

$$\Rightarrow dE_p \simeq \frac{1}{2}\,|\vec{T}|\left[\left(\frac{\partial z}{\partial r}\right)^2 dr + \frac{1}{r^2}\left(\frac{\partial z}{\partial \theta}\right)^2\right] r\,dr\,d\theta$$

$$\Rightarrow E_p \simeq \frac{1}{2}\,|\vec{T}| \int_0^a \int_0^{2\pi} \left[\left(\frac{\partial z}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial z}{\partial \theta}\right)^2\right] r\,dr\,d\theta$$