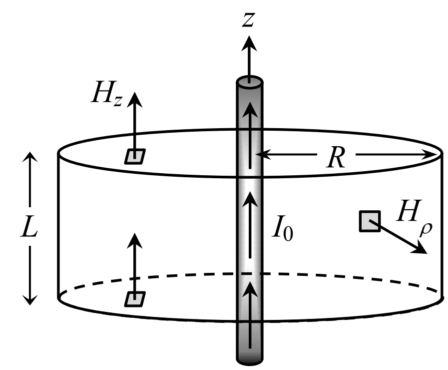
Problem 2.55) Consider a cylindrical can of arbitrary radius R and arbitrary length L centered on the wire, as shown in the figure below. We apply the integral form of Maxwell's 4th equation, $\boldsymbol{\nabla}\cdot\boldsymbol{B}=0$, to this can. Using Gauss's theorem, the integral form is found to be: $\oint \boldsymbol{B}\cdot d\boldsymbol{s}=0$. In the absence of magnetism, we have $\boldsymbol{M}=0$ and $\boldsymbol{B}=\mu_o\boldsymbol{H}$. Consequently, Maxwell's 4th equation demands that $\oint \boldsymbol{H}\cdot d\boldsymbol{s}=0$.



On the closed surface of the cylindrical can, only two components of the H-field contribute to the surface integral: (i) on the top and bottom facets, H_z has nonzero integrals; (ii) on the cylindrical surface, H_ρ makes a nonzero contribution to the integral. However, symmetry indicates that the contribution of H_z to the top facet is exactly cancelled out by its contribution to the bottom facet− because the value of H_z (whatever it may be) cannot depend on the z-coordinate. As for H_ρ, its magnitude must be the same everywhere on the cylindrical surface, again because of symmetry; its contribution to the surface integral will thus be $2\pi RLH_\rho$. The total integral of the H-field over the surface of the can is, therefore, $2\pi RLH_\rho$, which must be zero in accordance with Maxwell's 4th equation. We conclude that $H_\rho(\rho,\phi,z)$ must be zero everywhere.