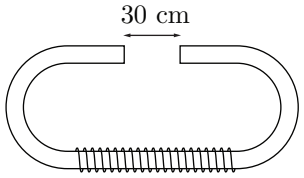
# M08E.3 - Electromagnet with an Iron Core

## Problem

A long solenoid is made from $N = 1000$ turns of wire, wound at 10 turns per cm. Recall that $\mu_0 = 4\pi \cdot 10^{-7}$ T m/A.

a) Give the approximate value in Tesla of the magnitude of the $B$-field at the center of the solenoid for $I = 100$ A of current.

b) Insert a soft-iron core through the solenoid and bend the two ends together leaving a uniform gap distance of 30 cm. The total length $L$ of the core is 3 meters and it has a constant cross-sectional area $A_{\text{core}} = 400$ cm$^2$. The relative permeability of the soft-iron is $\mu_r = 400$. Compute the magnitude of the $B$-field in the core $B_{\text{core}}$, and in the gap, $B_{\text{gap}}$, for a current $I = 100$ A. Assume that the $B$-field is uniform in the gap and there is no hysteresis.




c) Assume the maximum value of $B_{\text{core}} = 1.5$ T. New pole-faces are added to the gap that shorten the cap to 10 cm, but increase the cross-sectional area at the gap to $A_{\text{pole}} = 1600$ cm$^2$. The cross-sectional area of the core is unchanged. Compute the maximum value of $B_{\text{gap}}$ given the constraint on $B_{\text{core}}$ and the new pole-face geometry. Assume that the $B$-field is uniform in the gap and there is no hysteresis.