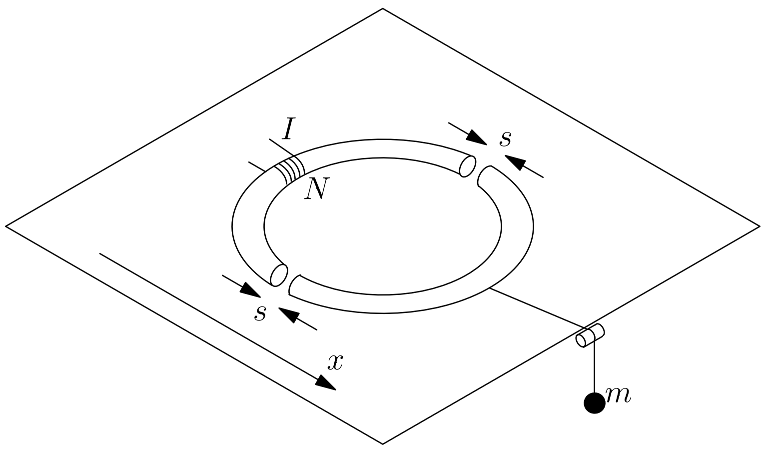
J06E.2 - Half Rings of Magnetic Material

Problem

A ring with relative permeability $\mu_r = 400$, minor radius $a = 1.5$ cm, and major radius $R = 50$ cm is placed on an horizontal (x-y) plane. The ring is cut transversally at two diametrically opposite points with the same x coordinate; the first half-ring is fixed to the plane, while the second can slide frictionlessly along the x direction (see figure below). A current $I = 0.8$ A (kept constant by an external power supply) flows into a solenoidal coil with $N = 800$ turns tightly wound on the first half of the ring. A mass m can hang from am massless wire connected to the second half-ring.



The two half-rings are initially touching, then they are pulled apart to a separation of distance $s = 3$mm (see figure), and two small cylindrical pieces of wood (with relative permeability $\mu_r' = 1$) are inserted into the gaps. Compute, giving *numerical answers* for parts c) and d):

a) The magnitudes of the magnetic fields $\boldsymbol{B}$ and $\boldsymbol{H}$ as a function of the separation s for $s \ll R$, both within the rings and within the gaps. You may assume that the fields are uniform within the ring, and within the gap, and negligible elsewhere.

b) The total magnetic energy as a function of the separation s for $s \ll R$.

c) The self-inductance of the coil after the separation ($s = 3$ mm).

d) The minimum value of the mass m needed to pull the second half-ring away from the wooden cylinders.