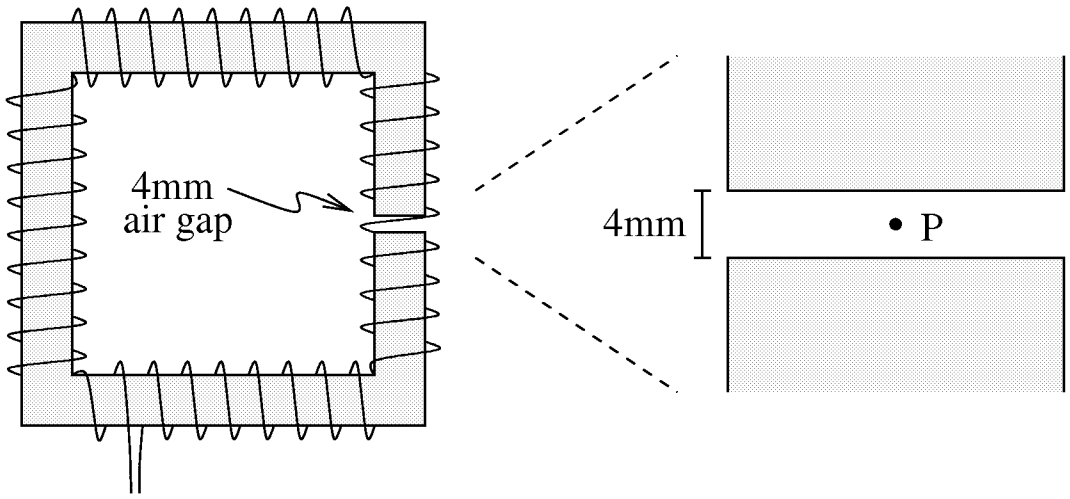
Problem 4 (22 points)

An iron bar which is 80 cm long is bent in a shape as shown. The ends of the bar do not touch; they are 4 mm apart. There is a coil with 1000 turns (see the figure). The current through the coil is 2 A. $\kappa_M = 200$ for the 80 cm long iron core. What is the approximate magnetic field strength (in Tesla) inside the air gap at P?



Problem 4 *(See homework problem 7.5.)*

The magnetic field lines will form closed loops, so the magnetic field strength will be approximately the same in the gap as in the bar. Taking this field strength to be roughly constant, we have

$$\oint \frac{1}{\kappa_M}\mathbf{B}\cdot d\boldsymbol{l} = \mu_0 I_{\substack{\text{piercing}\\ \text{surface}}} \quad\Longrightarrow\quad B\left(\frac{L}{\kappa_M}+d\right)\approx \mu_0 N I \quad ,$$

where $L = 80\,\text{cm}$, $d = 4\,\text{mm}$, $N = 1000$, and $I = 2\,\text{A}$. Solving for B:

$$B \approx \frac{\mu_0 N I}{L/\kappa_m + d} = \frac{(4\pi\times 10^{-7})(1000)(2)}{(0.8)/(200)+0.004} = \frac{\pi}{10}\,\text{T} \simeq 0.314\,\text{T} \quad .$$

~~Problem 5~~

~~**(a) TRUE:** The index of refraction is greater in water than in air, so the speed of light v is slower in water than in air. The wavelength is $\lambda = v/f$, so $v \downarrow \;\Rightarrow\; \lambda \downarrow$, as the frequency will not change.~~

~~**(b) TRUE:** The Poynting vector for a standing EM wave may be non-zero at an instant, but it will average to zero over one full period. Standing waves transmit no energy through space (See homework problem 9.4).~~

~~**(c) TRUE:** We have propagation in $-\hat{x}$ direction, with the maxima of E_y and E_z in phase with one another $\Rightarrow$ linear polarization (See homework problem 9.5).~~

~~**(d) TRUE:** Total internal reflection will occur when the angle of incidence $\theta_1 > \theta_c$, where θ_c is the angle of incidence for which the angle of refraction $\theta_2 = 90°$. From Snell's law, we find that $\sin\theta_c = n_2/n_1$. Thus θ_c depends on both n_1 and n_2 (but note that θ_c only exists if $n_1 > n_2$).~~

END