

Biot-Savart, ampère and magnetic sources

AP Physics C (Mechanics and E&M, calculus-based) · Lab answers

The answers use the sample table. Your gradient will depend on how evenly you wind the coil, how close the phone sensor sits to the axis and the local background field, but the graph should be a straight line through the origin with n close to the value you counted.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:E&M Unit 12

Question 1 Plot B against I

The points lie on a **straight line through the origin**, so B is proportional to I .

Question 2 Gradient

Gradient = $(1480 - 245)/(1.20 - 0.20) = 1235/1.00 = \mathbf{1.2 \times 10^3 \mu T/A}$ (1235 $\mu T/A$).

Question 3 Turns per metre

$n = \text{gradient}/\mu_0 = 1.235 \times 10^{-3}/(4\pi \times 10^{-7}) = \mathbf{9.8 \times 10^2 m^{-1}}$, which is 1.7 % below the counted 1000 m^{-1} , in agreement within error.

Question 4 Background field

The sensor also measures Earth's field (about 48 μT), which adds to the coil's field. Subtracting it, or **reversing I and halving the difference**, removes the offset.

Question 5 Uncertainty

Taking the current error: $0.02/0.20 = 10\%$ on the smallest value but 1.7 % on the largest; the gradient from the whole range has about **3 % uncertainty**.

Question 6 Finite coil

A coil of finite length has a weaker field at the centre than an infinitely long one. For $L = 0.20$ m and $D = 0.040$ m the factor is $L/\sqrt{L^2 + D^2} = 0.98$, a reduction of about **2 %**.

Question 7 Reducing error

Wind the wire in two layers on a longer tube to approach the infinite-solenoid limit, and use a more precise ammeter with shorter switch-on times so the coil does not heat and change

its resistance. Both give a **cleaner gradient**.