Magnetic Fields I

Name______________________________ ID______________________ TA_______________

Partners____

Date___________________________________ Section_________________________________

Please do not look into laser beam directly, and be careful about dealing with the equipment. It is heavy and fragile.

1. Calibration of the Current Balance

**Please measure in SI units, which are kilograms, meters, newtons, amps, teslas, and seconds.*

	Mass (kg)	Weight (N) [mass × g(9.8m/s^2)]	Deflection (m)
1	0		0
2	2.0 mg→ kg		
3	5.0 mg→ kg		
4	7.0 mg→ kg		
5	10.0 mg→ kg		
6	12.0 mg→ kg		

Calibration constant (slope of graph): k = ___________________________________(N/m)

2. Magnetic Field due to a Current in a Straight Wire

$x' =$ __________________________(m) ←Deflection due to the Ampere's force

$I =$ __________________________(A) $F = k \cdot x' =$ ________________________(N)

$\ell =$ __________________________(m) $r =$ ____________________________(m)

$B = \frac{F}{\ell I} =$ _____________________________(T) ←Experimental

$B = \frac{\mu_0 I}{2\pi r} = 2\times10^{-7}\frac{I}{r} =$ _____________________________(T) ←Theoretical

3. Percent Difference

$$\frac{|\text{Experimental } B - \text{Theoretical } B|}{\text{Theoretical } B} \times 100 = \underline{\hspace{6cm}}\%$$

4. Causes of Errors

Discuss some of the causes of errors in this experiment with your partners, and then enumerate at least three of them. Then write down some plausible improvements for those errors.

☑ Causes of errors:

☑ Solutions to minimize the errors:

Lab Procedure for Magnetic Fields

Please be careful about not looking into the laser beam. Please use SI units to calculate the experimental values appropriately.

1. Calibration of the Current Balance

- **Set up the apparatuses on the table appropriately as shown by the TA.**
  The bars' flowing currents must be exactly parallel. The distance between them should be about 1 centimeter (≈0.4 inches).

- **See if the mirror reflects the laser beam; put a paper on the wall to record the deflection displacements.**
  The TA provides the paper.

- **First, mark the spot position of the laser beam on the wall without the mass attached.**
  Try to mark the exact center of the spot.

- **Put the mass on the bar and mark the deflected spot position.**
  For this part (calibration), you do this with NO current.

- **Measure the deflection displacements with a meter stick.**
  Each displacement has to be measured from the original spot position, which was determined as 0 on the data sheet.

- **Calculate and express the values in SI units, and to get the calibration constant, put all values on the Excel File provided by the TA.**

  Units:
  1.0 mg → 1.0×10^{-6} (0.000001) kg, 1.0 mm → 1.0×10^{-3} (0.001) m
  Weight (N) = mass (kg) × gravitational acceleration (m/s^2)

  The Excel file provides the least square method, which is a systematic method to obtain the best-fit line from plotting. You can just put the deflection displacements and weight, and automatically you will get the slope, which is the constant, k.

2. Magnetic Field due to a Current in a Straight Wire

- **Connect banana plugs between the current source and the apparatus in the anti-parallel way.**
  The TA will show how to do this. If you are not sure, please ask him/her.

- **First, mark the spot position due to the laser beam with NO current.**
  The current source should be turned off during this measurement

- **Then turn on the power and adjust the current to 3 or 4 (Amps). However, if you do not get much deflection, just increase the current until about 7 Amps, but do not forget to turn it down. (The fuse in the power supply will blow up.) After the spot position stabilizes, you will mark the deflected one.**
  Due to Ampere's force, the bars repel each other.

- **Measure the displacement between two positions, and multiply it by 'k' obtained in the first part of experiment. Then you will get the force.**

- **Measure the length of the bar. Also you need to use SI units, meters here.**
  Only for the top one. The length should be the distance that the current is supposed to be flowing.

- **Calculate the experimental magnetic field, B.**
  You can read the current from the source. You already have bar length, ℓ, and the force F. Just plug them in the formula, $B = F/I\ell$. The unit is T (tesla).

- **Without current flow, measure the distance between bars. Then calculate the theoretical magnetic field.**
  From this measurement and the current value, you can calculate the theoretical one.
  $B = \mu_0 I/2\pi r = 2\times 10^{-7}\, I/r$. As you already notice, this should be close to the experimental one.