Summary 01: Magnetic Moments in the Magnetic Field

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1 Objective

In this experiment, we seek to find the torque due to magnetic moment, $\vec{T}$ in a uniform magnetic field: as a function of the strength of the magnetic field, as of the angle between the magnetic field, α in the magnetic moment or as the strength of the magnetic field. This is done by finding the respective magnetic moments for the 3 variables mentioned through the use of a torsion dynamometer and then plotting the magnetic moment against the exponent of the variables. Doing so will allow us to find the power constant in their relationship.

2 Introduction

A magnetic moment is defined as:

$$\vec{m} = \frac{1}{2}\oint_C \vec{r} \times d\vec{r} = I\oint_A d\vec{\Omega} \tag{1}$$

where I is the current, is the magnetic moment and A is any given area, the boundary of which is the closed conductor loop, C.

For the torque, acting on a magnetic moment, exerted by a magnetic field with constant flux density $\vec{B}$, it is represented by:

$$\vec{T} = \vec{m} \times \vec{B} \tag{2}$$

Therefore, for the present case in which the conductor loop is a flat current ring with diameter d and n turns:

$$\vec{m} = I \cdot n \cdot \vec{A} = I \cdot n \cdot \frac{\pi}{4}d^2 \tag{3}$$

where is the vector area of the current ring. If there is a current I' flowing in the Helmholtz ring, then from 1:

$$| \vec{T} |= c \cdot I \cdot n \cdot \frac{\pi}{4} d^2 \cdot I' \cdot sin\alpha \quad (4)$$

where the powers of the variables are what we need to verify.

3 Experimental Results

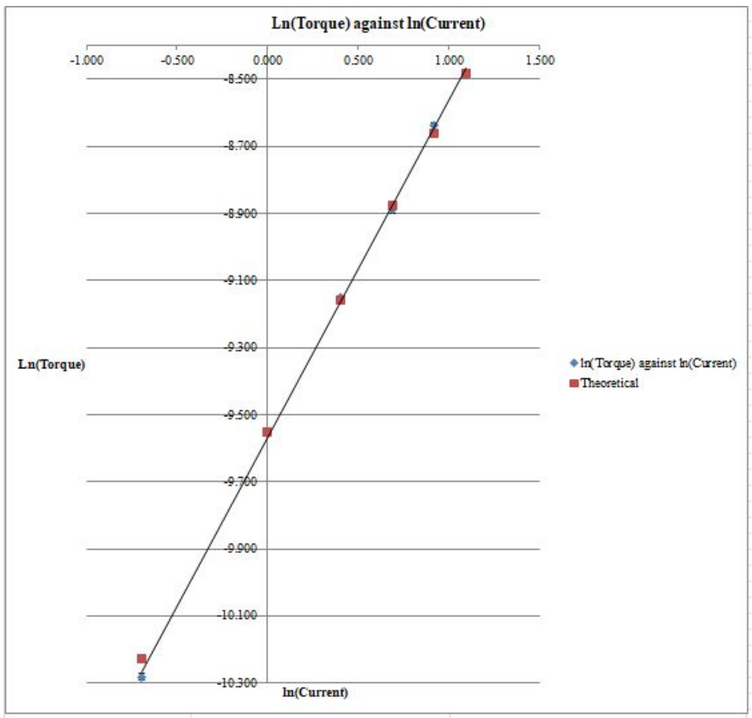

Figure 1: Graph of ln(torque) against ln(Current)

Through out the experiment, reading the value of torque obtained is rather difficult as it is an analogue reading. Turning the knob till it aligns with the black bar at the bottom is rather inaccurate due to the thickness of the bar. Therefore, turning the knob will give us various ranges of torque for the same alignment. This will affect the experiment as our results will deviate from the expected value. One way in which this can be fixed is by using a digital instrument instead. This ensure that the bar is perfectly aligned and therefore, will give us a more accurate result.

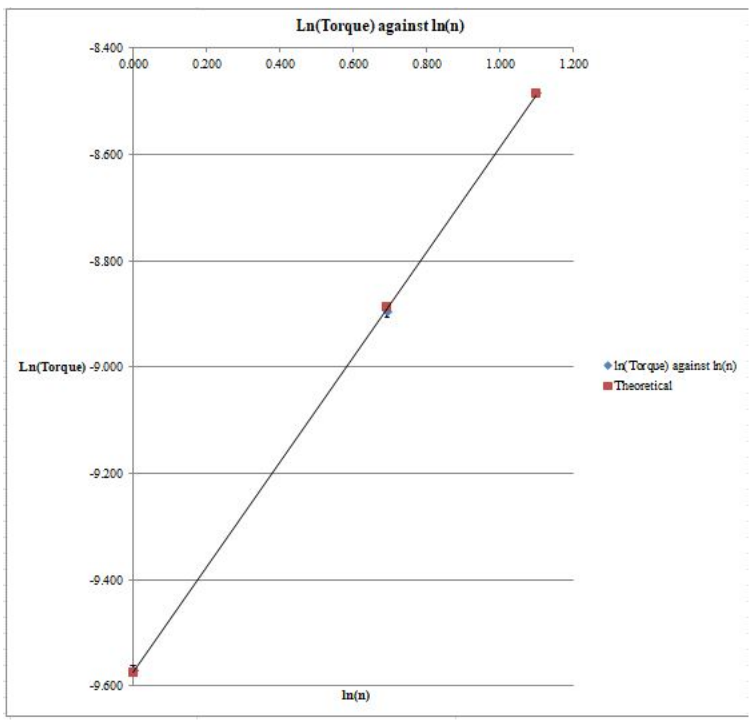

Figure 2: Graph of ln(torque) against ln(n)

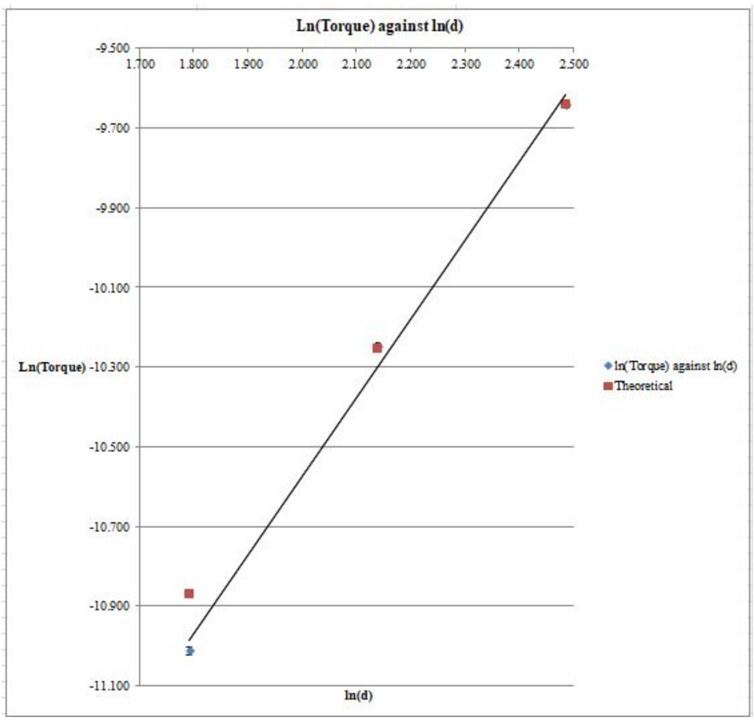

Figure 3: Graph of ln(torque) against ln(d)

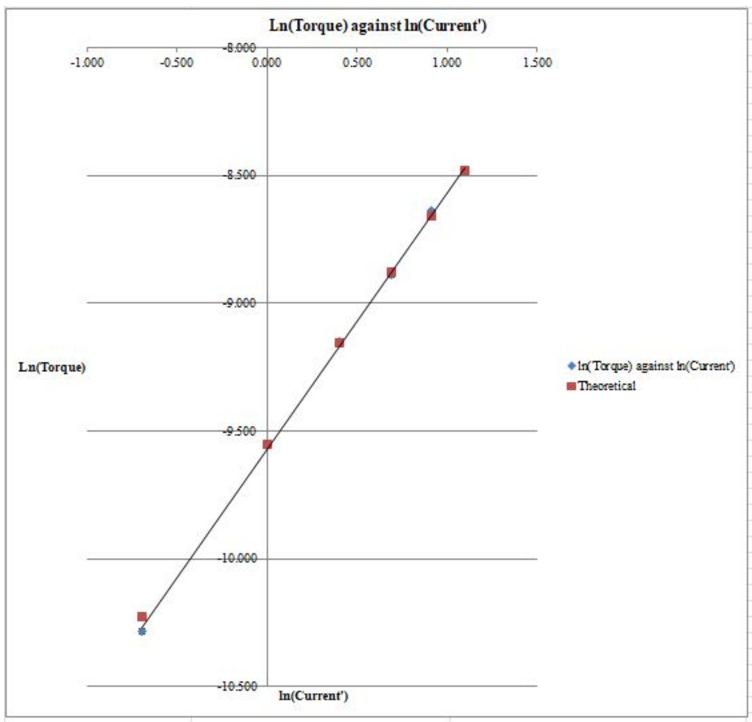

Figure 4: Graph of ln(torque) against ln(Current')

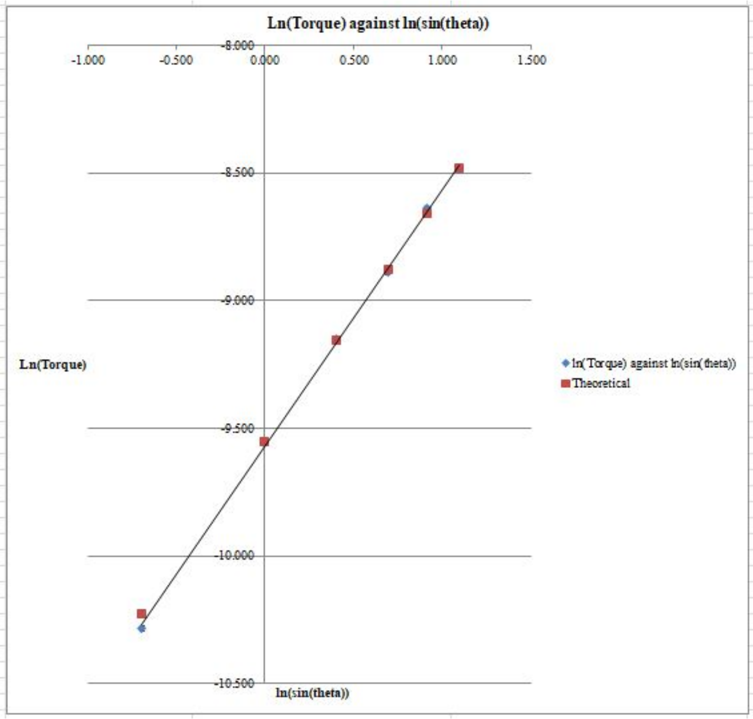

Figure 5: Graph of ln(torque) against ln(sin(theta))

Variable	Experimental value	Theoretical value	Percentage discrepancy
I	0.973919661	1	2.608033854
n	0.992531041	1	0.746895855
d	1.770107059	2	11.49464706
I'	1.040224399	1	4.022439883
sin(theta)	1.043066738	1	4.306673777

Figure 6: Graph of ln(torque) against ln(sin(theta))

Variable	Experimental c value	Theoretical c value	Percentage discrepancy
I	0.000756158	0.0006772	11.65950194
n	0.000747279	0.0006772	10.34832883
d	0.000727925	0.0006772	7.490425144
I'	0.000756299	0.0006772	11.68034085
sin(theta)	0.000859801	0.0006772	26.96412627
Average	0.000769493	0.0006772	13.62854461

Figure 7: Graph of ln(torque) against ln(sin(theta))

Variable	R^2 value
I	0.999822305
n	0.999997484
d	0.999880244
I'	0.995234816
sin(theta)	0.997373705

Figure 8: Graph of ln(torque) against ln(sin(theta))

1 Conclusion

The main goal of this experiment was to verify the torque due to magnetic moment, $\vec{T}$ in a uniform magnetic field: as a function of the strength of the magnetic field, as of the angle between the magnetic field, α in the magnetic moment or as the strength of the magnetic field. From our experimental values obtained for each power of variable, as seen in Fig(6), we were able to get a percentage discrepancy of less than 5%, aside from our value of Helmholtz constant and power of d. Getting a percentage discrepancy of less than 10% means that our experimental value agree with the theoretical value.

A reason for our experimental value for Helmholtz constant be higher than expected could be due to the experimental setup not being ideal. The coils might not have a uniform resistant. Furthermore, the analogue reading of the torque may not be accurate despite efforts as a range of values may be obtained for the same alignment. This all contributes to the discrepancy.

A reason for our experimental Hemlhotz constant to be larger than predicted might be due to our experimental setup not being ideal. The coils might not be of the same resistance, density of material or even thickness. Meanwhile, our reading of torque may be inaccurate due to analogue reading.

Our experimental results also have a high R^2 value of around 0.99, as seen in Fig(4). This signify that our data points highly match the linear trend predicted in Eqn(1).