电子科技大学
格拉斯哥学院
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Physics Experiment 02

Lab Report

Experiment Title:	Use Hall Effect to Measure Magnetic field
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Date Performed:	2018.6.8
Final Mark:	

Score

Abstract (About 100 words, 10 points)

The purpose of this experiment is to measure magnetic field by using Hall effect, analyzing how the position of Hall sensor in a solenoid and the excitation influence the magnetic induction B respectively. And the whole experiment is based on physics principles about electric and magnetic fields. An important part of it which eliminate the additional effects is that we change the directions of both excitation current I_M and Hall current I_H to get four voltages and then calculate the recorded data with zero readings. To study the relationship, we drew some graphs according to measured data and used the least-squares fitting method.

Score

Calculations and Results (Calculations, data tables and figures; 15 points)

3.2.6

(1) $$B=\frac{V_H}{kI_H}=\frac{\frac{(|V_1|+|V_2|+|V_3|+|V_4|)}{4}}{kI_H}=\frac{0.028mV}{171\times5.00mA}=0.03mT$$

(2) $$B=\frac{V_H}{kI_H}=\frac{\frac{(|V_1|+|V_2|+|V_3|+|V_4|)}{4}}{kI_H}=\frac{0.2375mV}{171\times5.00mA}=0.278mT$$

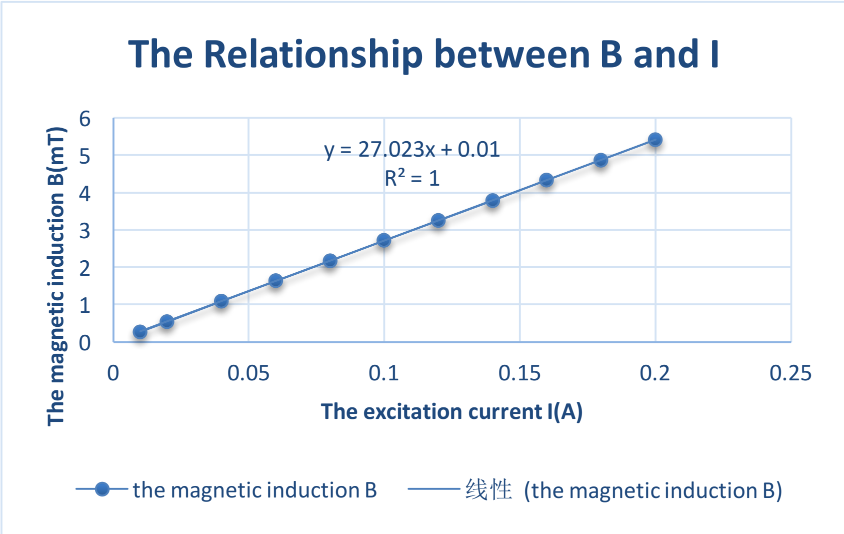
(3)

At the edge: $$B=\frac{\mu_0 N I_M}{2\sqrt{l^2+(\frac{D}{2})^2}}=\frac{4\pi\times10^{-7}\times3449\times0.0102}{2\sqrt{[(150.3)^2+(\frac{19.4}{2})^2]\times10^{-6}}}=1.47\times10^{-4}mT$$

At the center: $$B=\frac{\mu_0 N I_M}{2\sqrt{l^2+D^2}}=\frac{4\pi\times10^{-7}\times3449\times0.0102}{2\sqrt{[(150.3)^2+(19.4)^2]\times10^{-6}}}=2.92\times10^{-4}mT$$

(4) **By using the least-squares fitting method and the data in Data Table 3.2-3.**

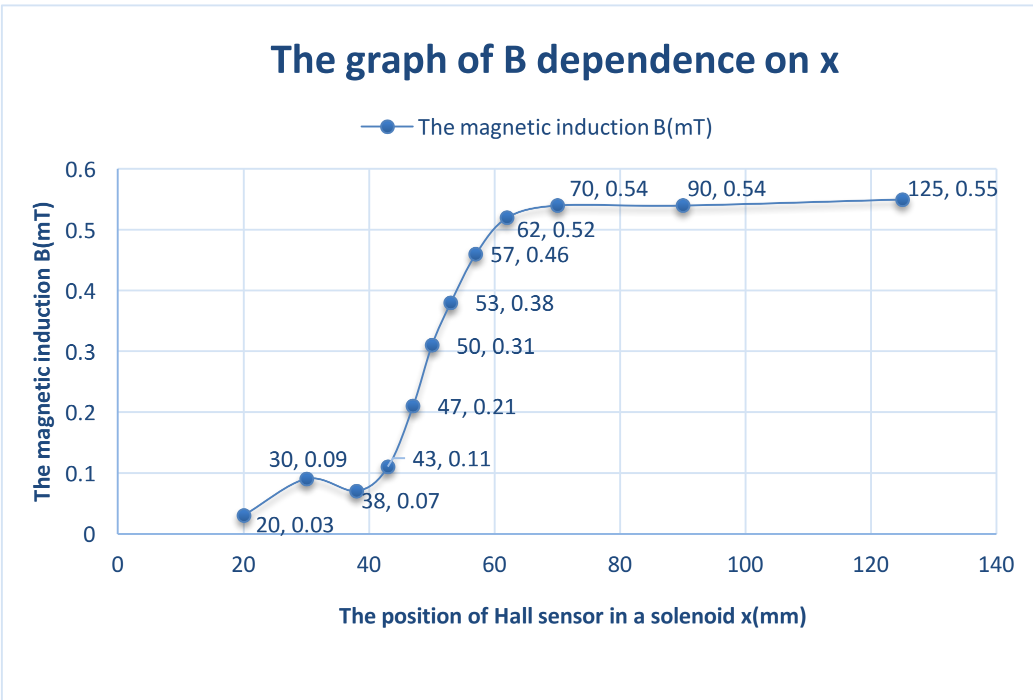
The final relationship: $B=0.01+27.023I_M$



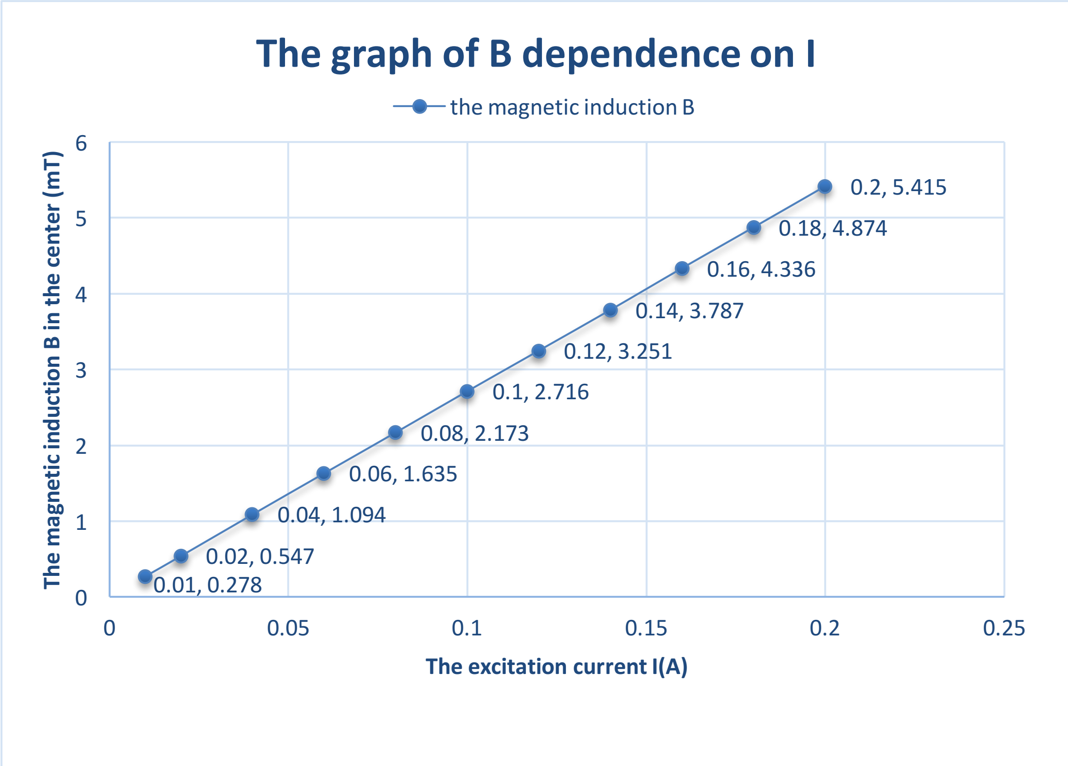
I	B
0.01	0.278
0.02	0.547
0.04	1.094
0.06	1.635
0.08	2.173
0.1	2.716
0.12	3.251
0.14	3.787
0.16	4.336
0.18	4.874
0.2	5.415

3.2.7

(1) The graph of the magnetic induction dependence on position of Hall sensor in a solenoid is showed as following:



(2) **The graph of the magnetic induction in the center of a solenoid dependence on the excitation current is showed as following:**



Score

Conclusions (About 100 words, 5 points)

On the basis of physics principles about electric and magnetic fields, we use Hall effect to measure magnetic field, and analyze how the position of Hall sensor in a solenoid and the excitation influence the magnetic induction B respectively. To make sure this experiment as accurate as possible, we used a huge variety of methods. Through the method of anti-direction to eliminate the additional effects (changing the directions of both excitation current I_M and Hall current I_H to get four voltages and then calculating the recorded data with zero readings). Besides, to study the relationship, we drew some graphs according to measured data and used the least-squares fitting method based on assuming that the magnetic induction B is a linear function of the excitation current I_M.

Score

Answers to Questions (10 points)

(1) To make Hall sensitivity be increased, we can get a stronger magnet or rise the velocity of particles.

(2) If we want to utilize the Hall effect to measure a magnetic field, we should digest fundamental principles and related information about experiment equipment for example, the material of the sensor is a semiconductor. The first step is to debug the experiment equipment before operating. After that we are supposed to put the censor in a tube and move in the magnetic tunnel perpendicularly to get many different results. Besides, we should change he voltage to get different groups of data. Inside the sensor, electric current is passed through the semiconductor. The Lorentz force is exerted on the moving electrons which push them to one side of the semiconductor. A buildup of charge at the sides of the semiconductor will balance this magnetic influence, producing a measurable voltage between the two sides of the semiconductor. And we need to use the method of anti-direction to eliminate the additional effects (changing the directions of both excitation current I_M and Hall current I_H to get four voltages and calculating the recorded data with zero readings) , and then use the formula $V_H = \frac{V_1 - V_2 + V_3 - V_4}{4}$.Finally, we calculate the result by the formula $B = \frac{V_H}{kI_H}$.

Appendix

(Scanned data sheets)

Data Table 3.2-1 ***Purpose*****: To record the instrument parameters for further calculations**

Hall Sensitivity, k /[mV (mA·T)]	Turns, N	Length, l /mm	Diameter, D /mm	Hall Current, I_H /mA
171	3449	150.3	19.4	5.00

Data Table 3.2-2 ***Purpose*****: To study the relationship between the magnetic induction** ***B*** **and the positions**

"Zero Readings"(I_M=0.0000 A): V_{01}= -11.01 mV, V_{02}= 12.34 mV, V_{03}= 12.33 mV, V_{04}= -10.98 mV, Excitation Current, I_M= 0.0102 A

Voltage/mV \ x / mm		20.0	30.0	38.0	43.0	47.0	50.0	53.0	57.0	62.0	70.0	90.0	125.0
V_1 ($+I_M$, $+I_H$)	*Readings*: V_1'	-10.97	-10.98	-10.90	-10.84	-10.70	-10.63	-10.55	-10.52	-10.46	-10.47	-10.44	-10.46
	$V_1 = V_1' - V_{01}$	0.04	0.1	0.11	0.17	0.31	0.38	0.46	0.49	0.55	0.54	0.57	0.55
V_2 ($+I_M$, $-I_H$)	*Readings*: V_2'	12.31	12.24	12.23	12.18	12.05	11.98	11.91	11.86	11.81	11.82	11.80	11.78
	$V_2 = V_2' - V_{02}$	-0.03	-0.1	-0.11	-0.16	-0.29	-0.36	-0.43	-0.48	-0.53	-0.52	-0.54	-0.56
V_3 ($-I_M$, $-I_H$)	*Readings*: V_3'	12.31	12.38	12.32	12.39	12.40	12.47	12.52	12.63	12.66	12.72	12.73	12.70
	$V_3 = V_3' - V_{03}$	-0.02	-0.06	-0.01	0.06	0.07	0.14	0.19	0.3	0.33	0.39	0.4	0.37
V_4 ($-I_M$, $+I_H$)	*Readings*: V_4'	-10.96	-10.95	-11.00	-10.97	-11.03	-11.14	-11.21	-11.28	-11.34	-11.38	-11.35	-11.39
	$V_4 = V_4' - V_{04}$	0.02	0.05	0.02	0.01	-0.06	-0.17	-0.23	-0.30	-0.36	-0.4	-0.35	-0.4
$V_H = \frac{1}{4}(V_1 - V_2 + V_3 - V_4)$		0.028	0.078	0.063	0.1	0.183	0.263	0.328	0.393	0.443	0.463	0.465	0.470
$B = V_H/kI_H$ /mT		0.03	0.09	0.07	0.11	0.21	0.31	0.38	0.46	0.52	0.54	0.54	0.55
B_{theory} / mT (Eqs. (3.2-8) and (3.2-9))							0.187						0.37
Relative error / %							38.4%						32.7%

Data Table 3.2-3 ***Purpose*: To study the relationship between the magnetic induction B in the center and the excitation current I_M**

"Zero Readings"(I_M=0.0000A): V_{01}=-11.01mV V_{02}=12.34mV V_{03}=12.33mV V_{04}=-10.98mV

Voltage/mV \ I_M / A		0.010	0.020	0.040	0.060	0.080	0.100	0.120	0.140	0.160	0.180	0.200
V_1 ($+I_M$, $+I_H$)	*Readings*: V_1'	-10.72	-10.49	-10.02	-9.55	-9.09	-8.62	-8.15	-7.68	-7.21	-6.75	-6.29
	$V_1 = V_1' - V_{01}$	0.29	0.52	0.99	1.46	1.92	2.39	2.86	3.33	3.8	4.26	4.72
V_2 ($+I_M$, $-I_H$)	*Readings*: V_2'	12.06	11.84	11.37	10.91	10.44	9.98	9.50	9.03	8.56	8.11	7.65
	$V_2 = V_2' - V_{02}$	-0.28	-0.5	-0.97	-1.43	-1.9	-2.36	-2.84	-3.31	-3.78	-4.23	-4.69
V_3 ($-I_M$, $-I_H$)	*Readings*: V_3'	12.53	12.77	13.23	13.69	14.15	14.61	15.04	15.49	15.96	16.42	16.88
	$V_3 = V_3' - V_{03}$	0.2	0.44	0.9	1.36	1.82	2.28	2.71	3.16	3.63	4.09	4.55
V_4 ($-I_M$, $+I_H$)	*Readings*: V_4'	-11.16	-11.39	-11.86	-12.32	-12.77	-13.24	-13.69	-14.13	-14.60	-15.07	-15.54
	$V_4 = V_4' - V_{04}$	-0.18	-0.41	-0.88	-1.34	-1.79	-2.26	-2.71	-3.15	-3.62	-4.09	-4.56
$V_H = \frac{1}{4}(V_1 - V_2 + V_3 - V_4)$		0.2375	0.4675	0.935	1.3975	1.8575	2.3225	2.78	3.2375	3.7075	4.1675	4.63
$B = V_H / kI_H$ /mT		0.278	0.547	1.094	1.635	2.173	2.716	3.251	3.787	4.336	4.874	5.415

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