☐PHYS115 ☐PHYS121 ☐PHYS123
☐PHYS116 ☐PHYS122 ☐PHYS124

Lab Cover Letter

Author (*You*) Trevor Swan Signature: Trevor Swan

I declare that this assignment is original and has not been submitted for assessment elsewhere, and acknowledge that the assessor of this assignment may, for the purpose of assessing this assignment: (1) reproduce this assignment and provide a copy to another member of faculty; and/or (2) communicate a copy of this assignment to a plagiarism checking service (which may then retain a copy of this assignment on its database for the purpose of future plagiarism checking).

Lab Partner(s) Pratham Bhashyakorla

Date Performed 3/25/25 Date Submitted 4/1/25

Lab (*such as #1: UNC*) #5: MAG/IND

TA: Samantha

GRADE (*to be filled in by your TA*) See your TA for detailed feedback.
An '*x*' next to a subcategory means you need to improve this aspect of your work.

Paper Subtotals (points)

( ) ***General* (6)**
_____ Sig. figs.
_____ Units
_____ Clarity of Presentation
_____ Format

( ) ***Abstract* (4)**
_____ Quantity or principle
_____ How measurement was made
_____ Numerical Results
_____ Conclusion

( ) ***Intro & Theory* (9)**
_____ Basic principle
_____ Main equations to be used
_____ Apparatus
_____ What will be plotted
_____ Fitting parameters related

( ) ***Exp. Procedures* (15)**
_____ Description
_____ Stating and justifying uncertainties
_____ Data Record
_____ Quality of Lab Work

( ) ***Analysis & Error Analysis* (20)**
_____ Discussion
_____ Equations & Calculations
_____ Presentation inc. Graphs, Tables
_____ Results Reported & Reasonable
_____ Underlined items addressed

( ) ***Discussion & Conclusions* (6)**
_____ Numerical comparison of results
_____ Logical conclusions
_____ Discussion of pos. errors
_____ Suggestions to reduce errors

( ) **Paper Total (60 points)**
(30 points for CME or EPF)

( ) **Notebook (10 points)**
_____ Format (*proper style, following directions*)
_____ Apparatus (*brief description of equipment, including sketches*)
_____ Data (*including computer file names and manually recorded data*)
_____ Experimental Technique (*describing your procedures; stating & justifying uncerts.*)
_____ Analysis (*results and errors*)

( ) **Worksheet(s)/Fill-in-the-Blank-Report (30 points)** *if applicable*

( ) **Adjustments** – late submissions, improper procedures, etc. – or bonus points for exceptional work.

( ) **Total Grade**

Graded by ___________ *(TA's initial)*

MAG Worksheet

Your Name: Trevor Swan **Signature:** [signature]

Lab partner(s): Pratham Bhashyakarla

Course & Section: PHYS122-118 **Station #** B **Date:** 4/1/25

---

1. For section D.3, Long Wire:
Attach a copy of one of the *LoggerPro* plots and your graph to this worksheet:

Report your value for the exponent of the power law as a measurement interval.

$-1.07 \pm 0.09 \ \frac{mT}{cm} \Rightarrow (-0.98, -1.16) \ \frac{mT}{cm}$

Is this consistent with the theoretical value? Explain.

constant $\times \frac{1}{r}$

For long straight wires theory shows $B = \frac{\mu_0 I}{2\pi r}$. Using a log10-log10 plot, we expect a slope of -1 derived using a linear fit. The interval above captures -1 in its lower and upper limits. This means that the power law is a proper model for this experiment. Our slope of $-1.07 \pm 0.09 \ \frac{mT}{cm}$ is consistent with the theoretical value.

2. For section D.4, Coils:
Attach a copy of your graph to this worksheet:

Report your value for the exponent of the power law as a measurement interval.

$-0.98 \pm .22 \ \frac{mT}{cm} \Rightarrow (-0.76, -1.20) \ \frac{mT}{cm}$

Is this consistent with the theoretical value? Explain.

For coils and magnets, theory shows $B = \frac{\mu_0 N i R^2}{2z^3}$ for $z \gg R$ like in our situation. This reduces to a constant time $\frac{1}{z^3}$, suggesting a cubic relationship. Thus a log10-log10 plot should yield a slope of -3. This is not consistent with the bounds presented above. Ultimately, the power law, $-0.98 \pm 0.22 \frac{mT}{cm}$, is inconsistent with theory, suggesting errors in our experimental method or in the model derivation.

3. For section D.5, Disk Magnet:

Attach a copy of your graph to this worksheet:

Report your value for the exponent of the power law as a measurement interval.

$-2.91 \pm 0.09 \frac{mT}{cm} \Rightarrow (-2.82, -3.00) \frac{mT}{cm}$

Compare this value to your value for the coil.

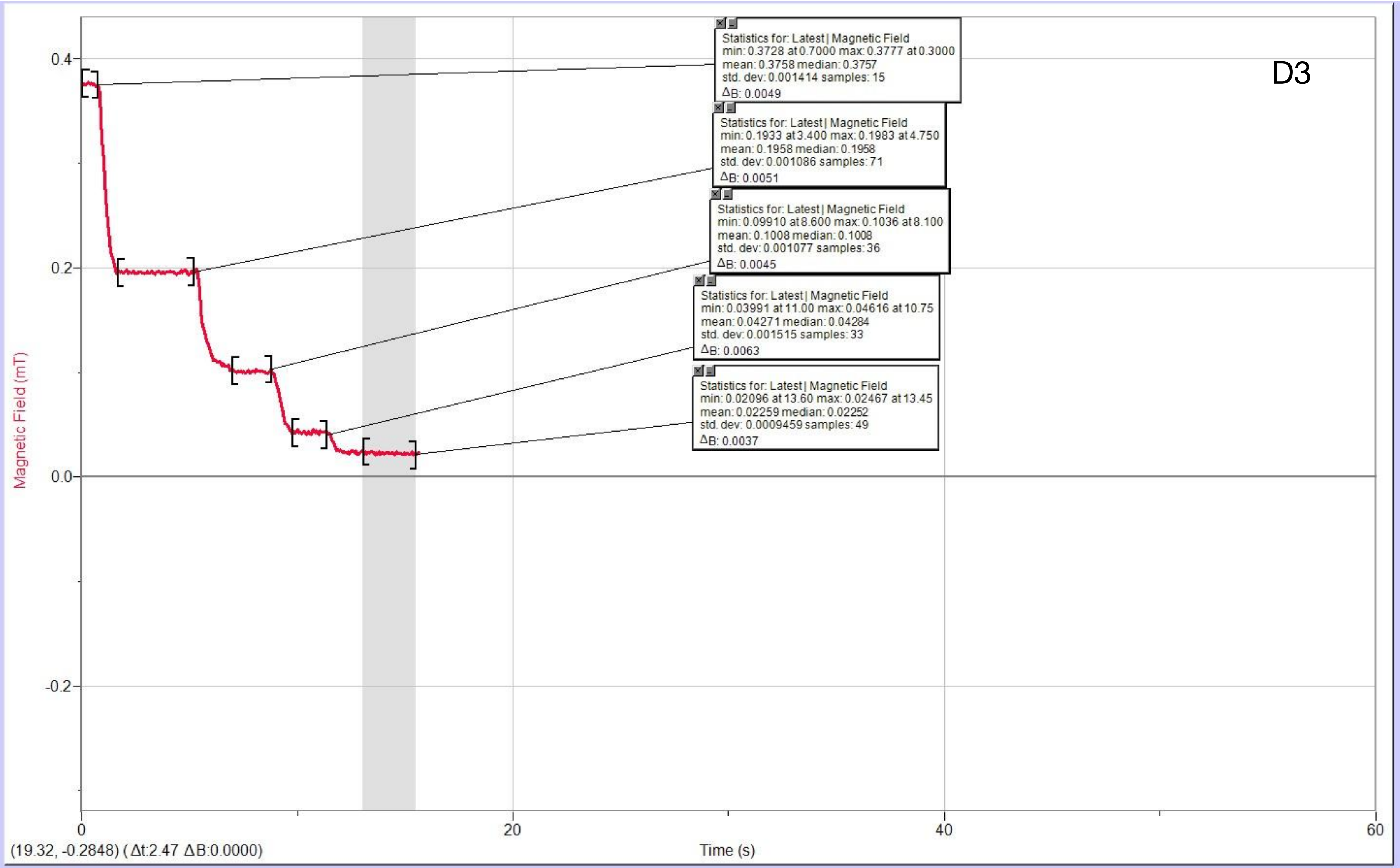
As discussed in Q2, the slope should be -3. This theoretical value is consistent with the lower value in our range. The power law is thus a good model for this data. The fact that this value is in agreeance with theory, but the coil was not, suggests a fundamental error in the way we performed the second experiment in this section of the lab. Ultimately, this measurement value and hence the power law slope of $-2.91 \pm 0.09 \frac{mT}{cm}$ is in agreeance with theory and is better than the value for the coil.

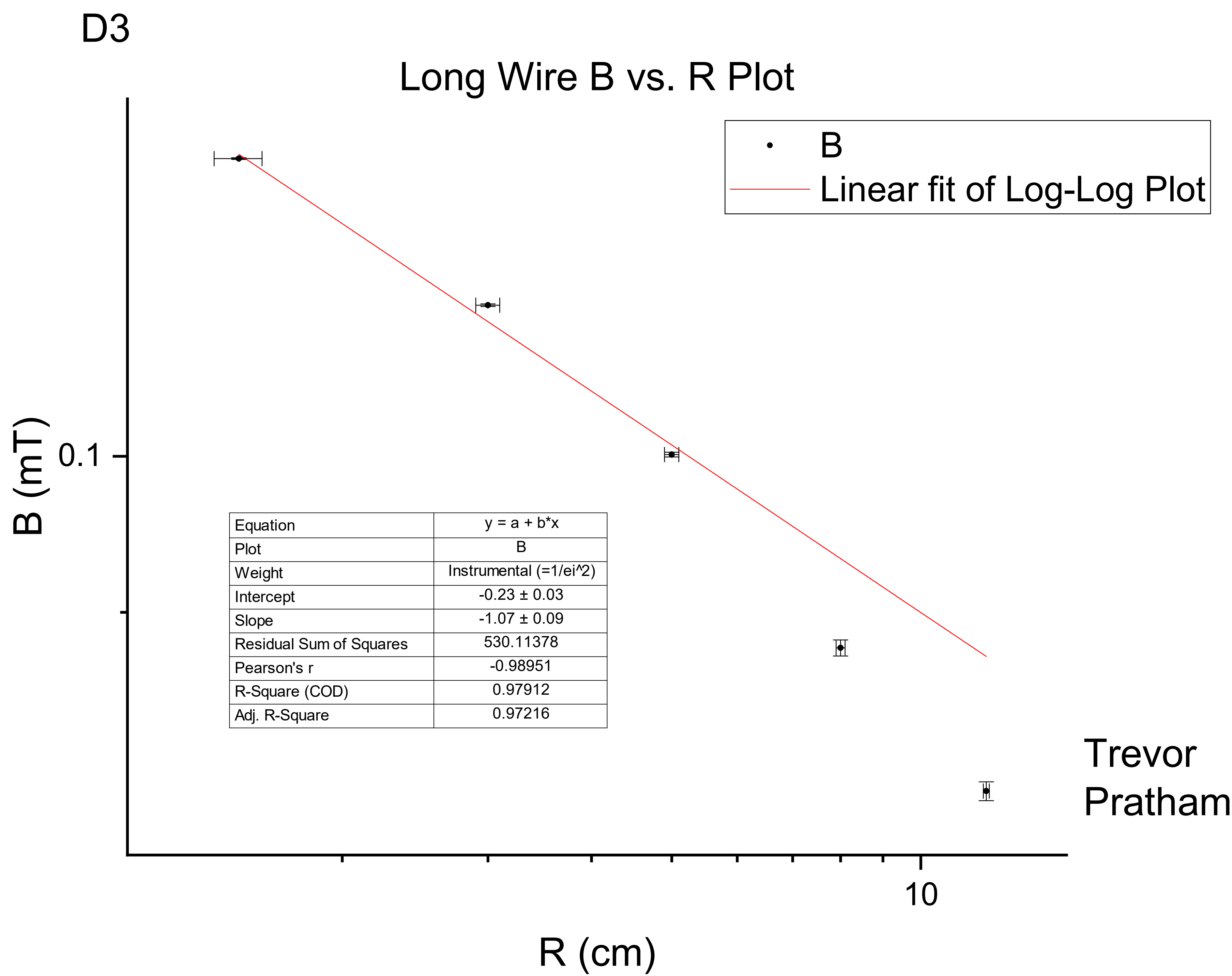
GRADE:_______ (out of 30 points)

GRADED BY ________ (TA's initials)

	Latest	
	Time (s)	B (mT)
230	11.45	0.0417
231	11.50	0.0419
232	11.55	0.0401
233	11.60	0.0358
234	11.65	0.0344
235	11.70	0.0313
236	11.75	0.0274
237	11.80	0.0253
238	11.85	0.0256
239	11.90	0.0258
240	11.95	0.0249
241	12.00	0.0262
242	12.05	0.0251
243	12.10	0.0237
244	12.15	0.0243
245	12.20	0.0237
246	12.25	0.0233
247	12.30	0.0227
248	12.35	0.0241
249	12.40	0.0219
250	12.45	0.0227
251	12.50	0.0243
252	12.55	0.0253
253	12.60	0.0249
254	12.65	0.0229
255	12.70	0.0253
256	12.75	0.0221
257	12.80	0.0219
258	12.85	0.0217
259	12.90	0.0233
260	12.95	0.0235
261	13.00	0.0251
262	13.05	0.0237
263	13.10	0.0215

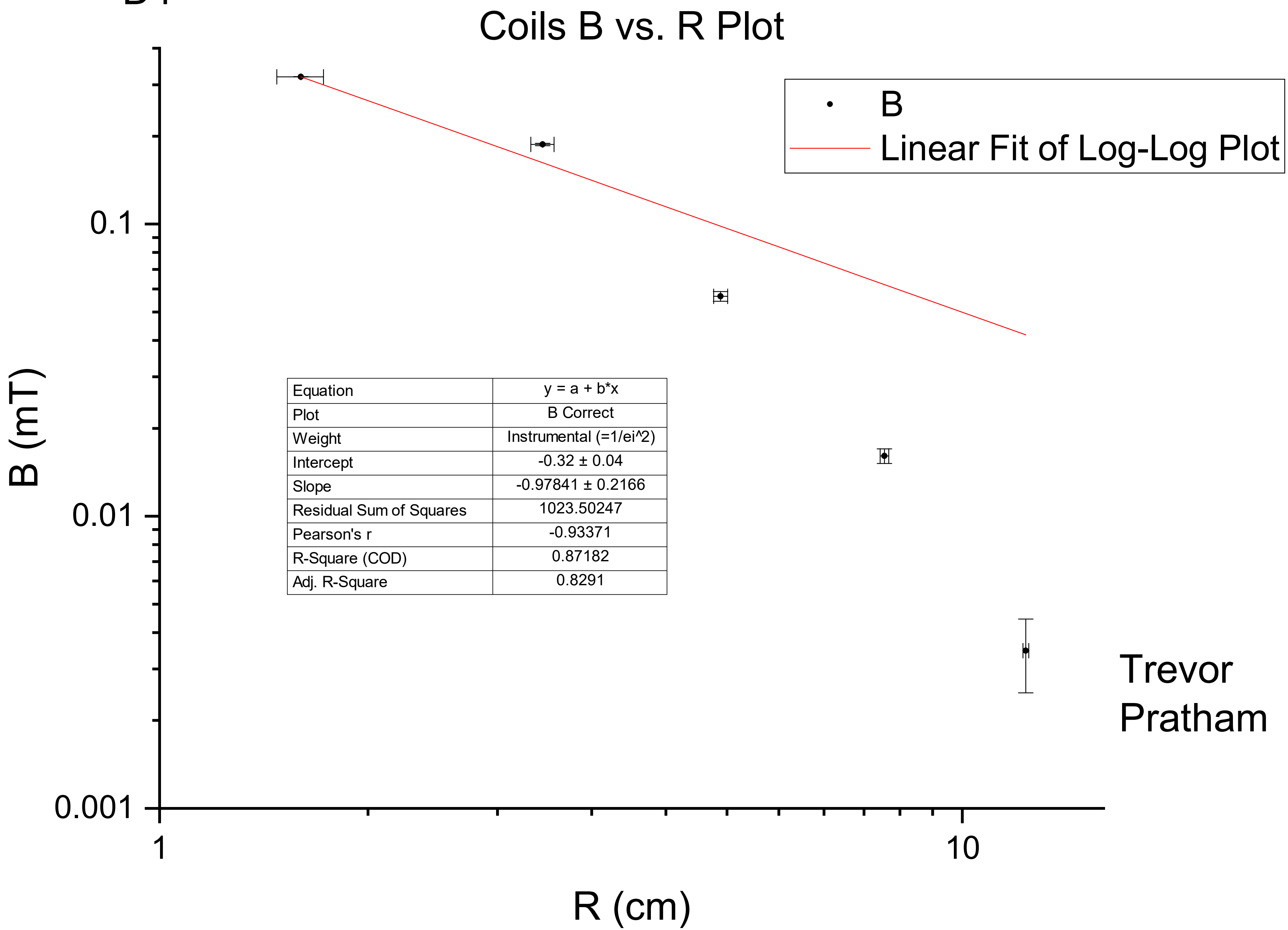
Magnetic Field
-0.0238 mT





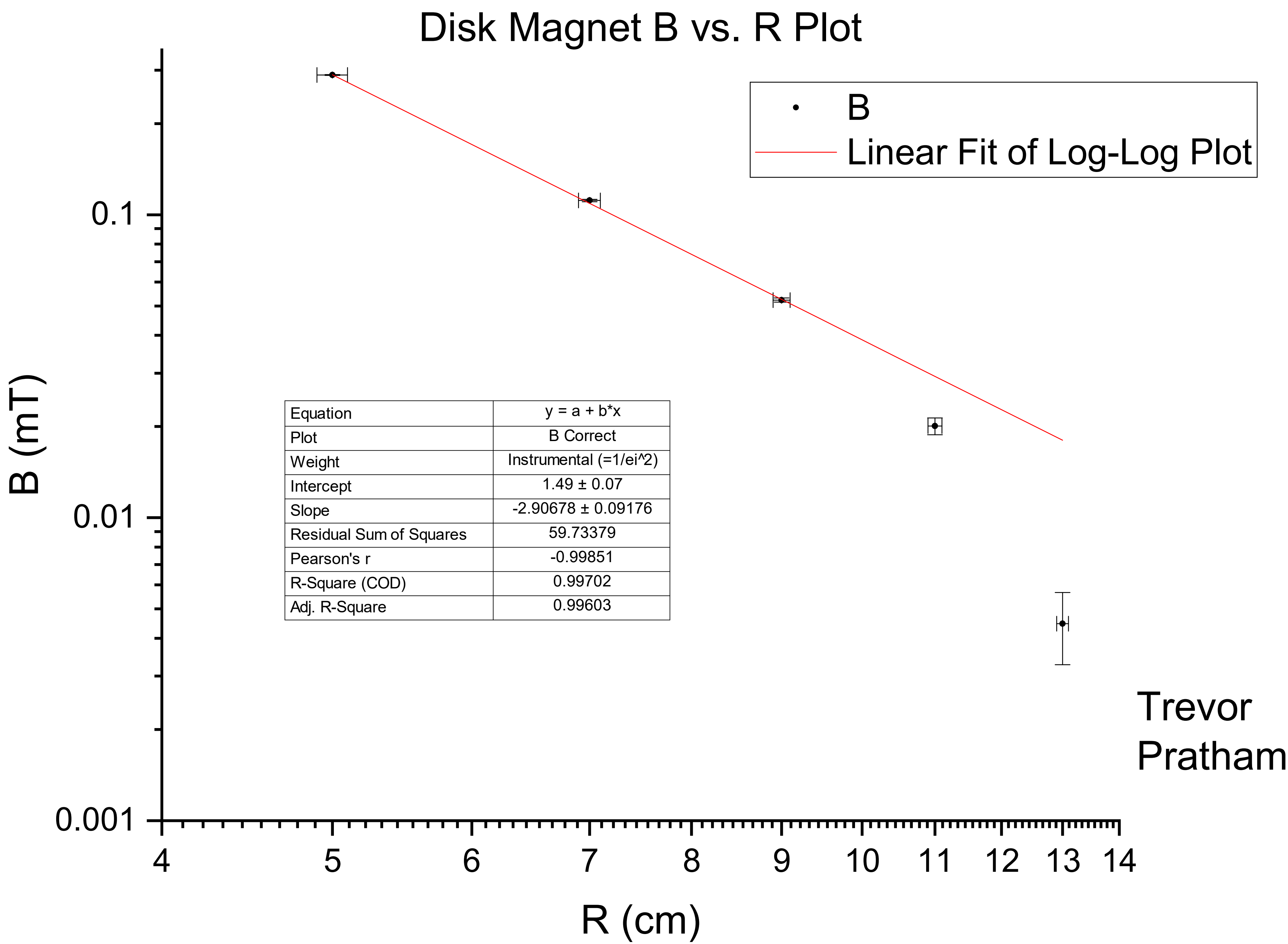
Equation	y = a + b*x
Plot	B
Weight	Instrumental (=1/ei^2)
Intercept	-0.23 ± 0.03
Slope	-1.07 ± 0.09
Residual Sum of Squares	530.11378
Pearson's r	-0.98951
R-Square (COD)	0.97912
Adj. R-Square	0.97216

D4



Equation	y = a + b*x
Plot	B Correct
Weight	Instrumental (=1/ei^2)
Intercept	-0.32 ± 0.04
Slope	-0.97841 ± 0.2166
Residual Sum of Squares	1023.50247
Pearson's r	-0.93371
R-Square (COD)	0.87182
Adj. R-Square	0.8291

D5


Disk Magnet B vs. R Plot
B
Linear Fit of Log-Log Plot
B (mT)
0.1
0.01
0.001
R (cm)
4
5
6
7
8
9
10
11
12
13
14
Equation | y = a + b*x
Plot | B Correct
Weight | Instrumental (=1/ei^2)
Intercept | 1.49 ± 0.07
Slope | -2.90678 ± 0.09176
Residual Sum of Squares | 59.73379
Pearson's r | -0.99851
R-Square (COD) | 0.99702
Adj. R-Square | 0.99603
Trevor
Pratham

IND Worksheet

Revised March 30, 2017

Your Name: Trevor Swan **Signature:** [signature]

Lab partner(s): Pratham Bhashyakarla

Course & Section: PHYS122-118 **Station #** 13 **Date:** 4/1/25

1. For section D.2.2, with the rectangular coil:

What was the largest (positive or negative) induced EMF you found for:

i. motion of the coil outside the magnet, about 40 cm away: -.0073 V

ii. motion over the magnet with coil ends kept from crossing the boundary: 0.012V

iii. 40 cm-to-center motion: 0.615V ; center-to-40 cm: -0.606V

Explain why the sign of the EMF change between these two directions.

This is explained by Lenz's law. Moving toward the coil, the flux increases, produces a positive EMF. When you move away from the magnet, the flux decreases → negative EMF. The sign change occurs because the direction of the coil's current must oppose the change in flux.

Record the values of the integrals for each part of the motion (*Don't forget units.*):

40 cm-to-center motion: 0.061 V·s ; center-to-40 cm: -0.064 V·s

Why should these two integrals be equal in magnitude and opposite in sign.

The integrals represent the flux change in each direction/motion. Since the fluxes are equal in mag and opposite in sign as explained by Lenz's law, the areas under the two peaks must also be equal in mag. and opposite in sign.

Remember to attach a copy of your *LoggerPro* scan for measurement iii.

iv. Record the maximum magnitude of the EMF for your two other speeds?

Motion 40 cm to center: slower: 0.046 V faster: 0.74 V

motion center to 40 cm: slower: -0.063 V faster: -0.56 V

Explain why the magnitude changed with speed.

Faraday's law relates $d\Phi_B$ with dt. When moving faster, the rate of change in flux with respect to time is larger as flux changes more rapidly than when moving slowly resulting in EMF being larger for faster motions.

Record the value of the integral over time of the EMF for

fast motion: 0.058 V·s slow motion: : 0.16 V·s

obviously not!

Are the integrals for the two different speeds the same? Should they be? Explain why or why not.

This is expected. The integral is represented by EMF × time. When we move quickly, the EMF is large, but the motion is short. As time is so low, EMF × time, the integral will be small. For the slow motion, time is much greater, results in a larger integral despite slow motion. Ultimately, since the integral depends on both EMF mag and time, a slower motion results in a larger total integral.

v. Record the values of the integrals for:

moving the coil onto the magnet: 0.06 V·s lifting it up and back: − 0.06 V·s

Are these values equal but opposite? Yes! Is this behavior expected? Explain why or why not.

Flux is what determines the values through Lenz's law. The total magnetic flux through the coil when moving up remains constant. But changes as the horizontal difference changes. The towards and away motions should be symmetric as explained previously. Vertically there is no change in flux so this result is expected to be the same.

2. For section D.3 with rotating coils: (*Attach a copy of the printout as requested.*)

Record the values of the integrated areas for the 90º flips? (*average of two values*)

$\frac{0.01462 + .02369}{2}$

Fast: 0.19 V·s Slow: 0.16 V·s $0.0127 + .0193$

Record the average time integral for your four 180° flips. 0.032 V·s $= \frac{0.03229 + .03433 + .03175 + .02849}{4}$

Determine the strength of the magnet from these flips. 1.30×10^{-5} mT or 0.130 T

2BA for one loop

$I_{nt} = 2BAN$ $A = 0.77\ cm^2$, $N = 1600$ turns

$B = \frac{I}{2AN} = \frac{0.032\ V\cdot s}{2(0.77\ cm^2)(1600)} = 1.30 \times 10^{-5}\ mT$

3. Section D.4 - Coupled Circuits

Explain the shape of the induced waveform in relation to the input waveform.

The induced waveform mirrors the input waveform due to the relationship between the rate of change of magnetic flux due to the current and induced EMF. A square input results in sharp, square like pulses, while a sine wave input results in a smooth sinusoidal induced waveform. Changes in amplitude/period are due to the coils characteristics (like number of turns)

$\frac{3.029 - .1316}{2}$ What are the EMFs for the coils with different number of turns at 20Hz?

16 turn: 1.45 mV 160 turn 14.47 mV 1600 turn 28.73 mV

160: $\frac{16 + 12.94}{2}$ 1600: $\frac{35.10 + 22.35}{2}$

Compare this behavior to theory.

Decreasing the number of turns by a factor of 10 should do the same to the EMF in theory, but this only holds for 160 → 16 turns. A factor of 2 for 1600 → 160 suggests experimental or measurement error!

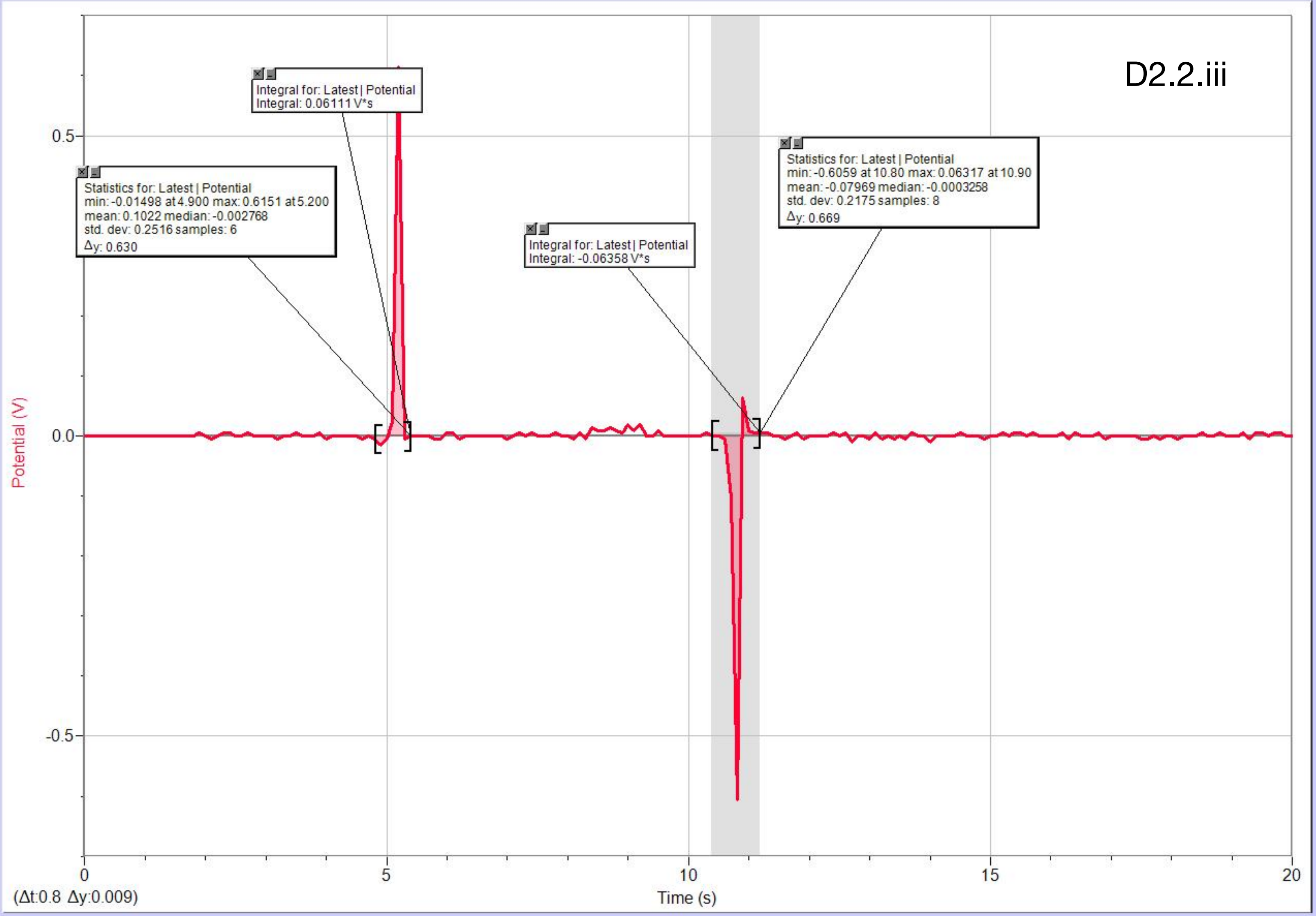
$\frac{1600 =}{160 =} \frac{28.73}{14.47} = 1.99$

$\frac{160 =}{16 =} \frac{14.47}{1.45} = 9.98$

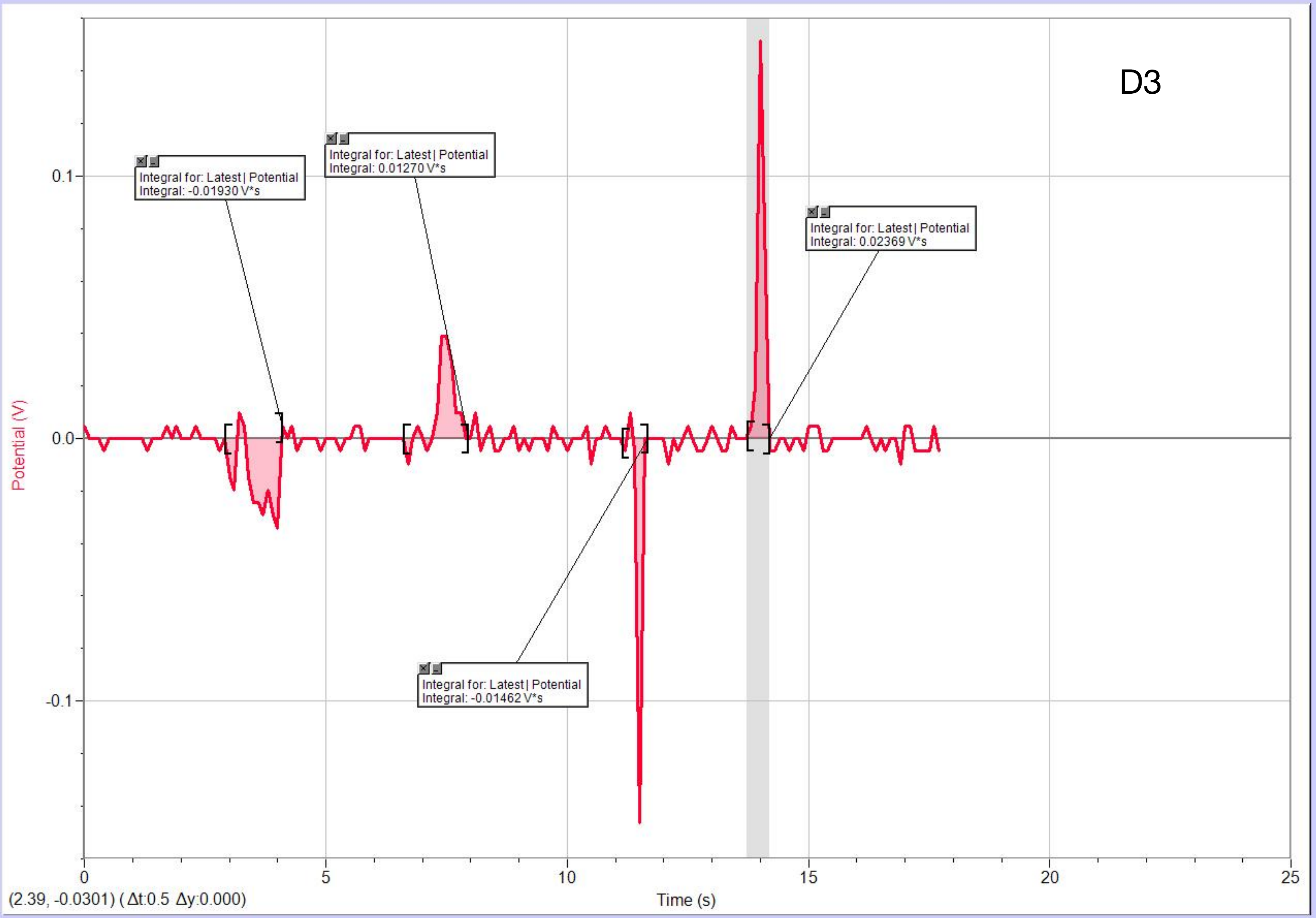
GRADE:_______ (out of 30 points)

GRADED BY ________ (TA's initials)

	Latest	
	Time (s)	Potential (V)
65	6.4	0.000
66	6.5	0.000
67	6.6	0.000
68	6.7	0.000
69	6.8	0.000
70	6.9	0.000
71	7.0	-0.005
72	7.1	0.000
73	7.2	0.005
74	7.3	0.000
75	7.4	0.005
76	7.5	0.000
77	7.6	0.000
78	7.7	0.000
79	7.8	0.005
80	7.9	0.000
81	8.0	0.000
82	8.1	-0.005
83	8.2	0.005
84	8.3	-0.005
85	8.4	0.014
86	8.5	0.009
87	8.6	0.009
88	8.7	0.014
89	8.8	0.009
90	8.9	0.005
91	9.0	0.019
92	9.1	0.009
93	9.2	0.019
94	9.3	0.000
95	9.4	0.000
96	9.5	0.009
97	9.6	0.000
98	9.7	0.000
99	9.8	0.000
100	9.9	0.000
101	10.0	0.000
102	10.1	0.000
103	10.2	0.000
104	10.3	0.005
105	10.4	0.000
106	10.5	0.000



	Latest	
	Time (s)	Potential (V)
99	9.8	0.000
100	9.9	0.000
101	10.0	-0.005
102	10.1	0.000
103	10.2	0.000
104	10.3	0.000
105	10.4	0.005
106	10.5	-0.010
107	10.6	0.000
108	10.7	0.000
109	10.8	0.005
110	10.9	0.000
111	11.0	0.000
112	11.1	0.000
113	11.2	-0.005
114	11.3	0.010
115	11.4	-0.005
116	11.5	-0.147
117	11.6	0.000
118	11.7	0.000
119	11.8	0.000
120	11.9	0.000
121	12.0	0.000
122	12.1	-0.010
123	12.2	0.000
124	12.3	-0.005
125	12.4	0.000
126	12.5	0.005
127	12.6	0.000
128	12.7	-0.005
129	12.8	-0.005
130	12.9	0.000
131	13.0	0.005
132	13.1	0.000
133	13.2	-0.005
134	13.3	-0.005
135	13.4	0.005
136	13.5	0.000
137	13.6	0.000
138	13.7	0.000
139	13.8	0.005
140	13.9	0.020



	Latest		
	Time (s)	Potential 1 (mV)	Potential 2 (V)
1	0.000	-5.13	4.066
2	0.001	-2.60	4.061
3	0.002	-1.01	4.061
4	0.003	-0.05	4.061
5	0.004	0.57	4.061
6	0.005	0.95	4.056
7	0.006	1.19	4.061
8	0.007	1.32	4.061
9	0.008	1.42	4.061
10	0.009	1.50	4.061
11	0.010	1.53	4.061
12	0.011	1.55	4.061
13	0.012	1.55	4.061
14	0.013	1.56	4.061
15	0.014	1.58	4.061
16	0.015	1.58	4.061
17	0.016	34.93	0.002
18	0.017	34.91	0.002
19	0.018	34.89	0.002
20	0.019	34.91	-0.002
21	0.020	34.88	-0.002
22	0.021	35.02	-0.007
23	0.022	35.07	0.007
24	0.023	27.25	0.002
25	0.024	18.27	-0.007
26	0.025	12.41	-0.002

Potential 1
-3.05 mV

Potential 2
1.354 V