

PAG 9.1 Charging and discharging capacitors (iii) writeup

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t / s	I / A				
	1	2	3	4	5
0	0.118	0.119	0.117	0.117	0.120
5	0.101	0.100	0.100	0.100	0.100
10	0.083	0.082	0.082	0.080	0.082
15	0.065	0.062	0.066	0.067	0.065
20	0.054	0.054	0.055	0.054	0.055
25	0.045	0.044	0.044	0.043	0.044
30	0.036	0.036	0.036	0.036	0.035
35	0.029	0.029	0.029	0.029	0.029
40	0.024	0.024	0.024	0.024	0.024
45	0.020	0.019	0.019	0.019	0.019
50	0.016	0.016	0.016	0.016	0.016
55	0.013	0.013	0.013	0.013	0.013
60	0.011	0.010	0.010	0.010	0.010
65	0.009	0.009	0.009	0.009	0.009
70	0.007	0.007	0.007	0.007	0.007
75	0.006	0.006	0.006	0.006	0.006
80	0.005	0.005	0.005	0.005	0.005
85	0.004	0.004	0.003	0.004	0.004
90	0.003	0.003	0.003	0.003	0.003
95	0.002	0.002	0.002	0.002	0.002
100	0.002	0.002	0.002	0.002	0.002
105	0.001	0.001	0.001	0.001	0.001

Table 1: Discharging data

```
1 library(ggplot2)
2
3 U_I <- 0.002
4 U_t <- 1
5 charge_df <- read.table("data.csv", sep=",")
6 colnames(charge_df) <- c("t", "I1", "I2", "I3", "I4", "I5")
7 charge_df$I_avg <- rowMeans(charge_df[c("I1", "I2", "I3", "I4", "I5")])
8 m <- nls(I_avg~I0*exp(-t/tau), start=list(I0=head(charge_df$I_avg, n=1),tau=25),
9   ↪ data=charge_df)
9 m
10 qplot(t, I_avg, data=charge_df, main="Current in RC circuit over time",
```

```

11   xlab="t / s", ylab="I / A") +
12   geom_errorbar(data=charge_df, mapping=aes(ymin=I_avg-U_I, ymax=I_avg+U_I)) +
13   geom_errorbarh(data=charge_df, mapping=aes(xmin=t-U_t, xmax=t+U_t)) +
14   theme(panel.grid.minor = element_line(colour="gray", size=0.4),
15         panel.grid.major = element_line(colour="gray", size=1),
16         panel.background = element_blank()) +
17   scale_y_continuous(minor_breaks = seq(0, 0.12, 0.002), breaks = seq(0, 0.12,
18     ↪ 0.01)) +
19   scale_x_continuous(minor_breaks = seq(0, 110, 2), breaks = seq(0, 110, 10)) +
  geom_line(aes(y = predict(m)), color="steelblue")

```

Listing 1: R source

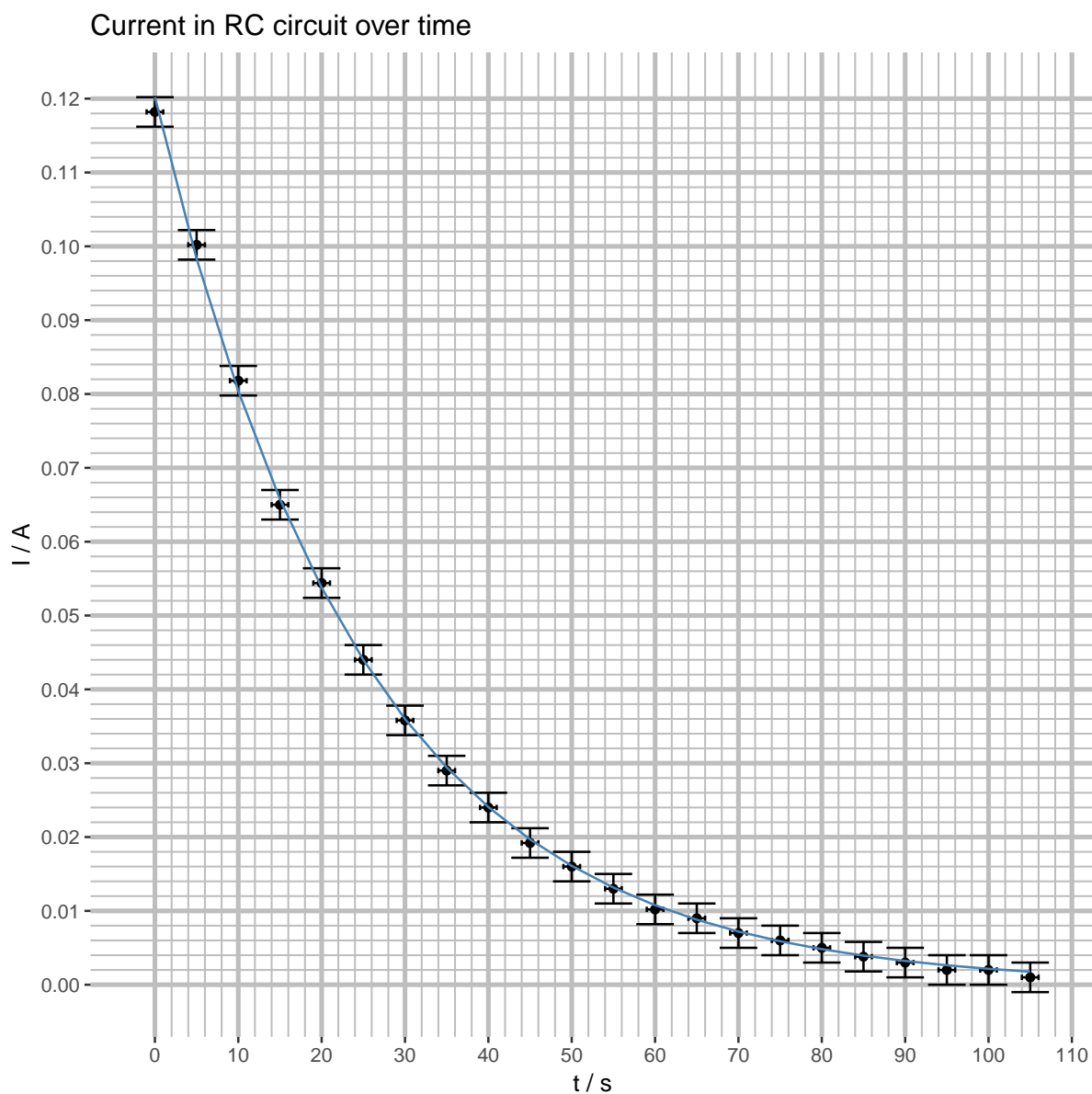


Figure 1: Generated graph

```
2  model: I_avg ~ I0 * exp(-t/tau)
3  data: charge_df
4      I0      tau
5  0.1202 24.8685
6  residual sum-of-squares: 1.25e-05
7
8  Number of iterations to convergence: 3
9  Achieved convergence tolerance: 9.243e-07
```

Listing 2: Model results

The resistance was also measured at $47\text{k}\Omega$. This can be combined with the fitted value $\tau = 24.8685\text{ s}$, to find

$$C = \frac{RC}{R} = \frac{24.8685}{47 \cdot 10^3} = 5.2911 \times 10^{-4} \text{ F}$$