Lab Experiment #8:

Simple AC Circuits: Reactance and impedance

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PHYS 220BL
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Data

Inherent values of elements

R (Ω)	Internal R of inductor (Ω)	C (F)
$2.728 \times 10^3 \Omega$	136.7Ω	$21.45\mathrm{nF}$

Current for 4 circuit configurations:

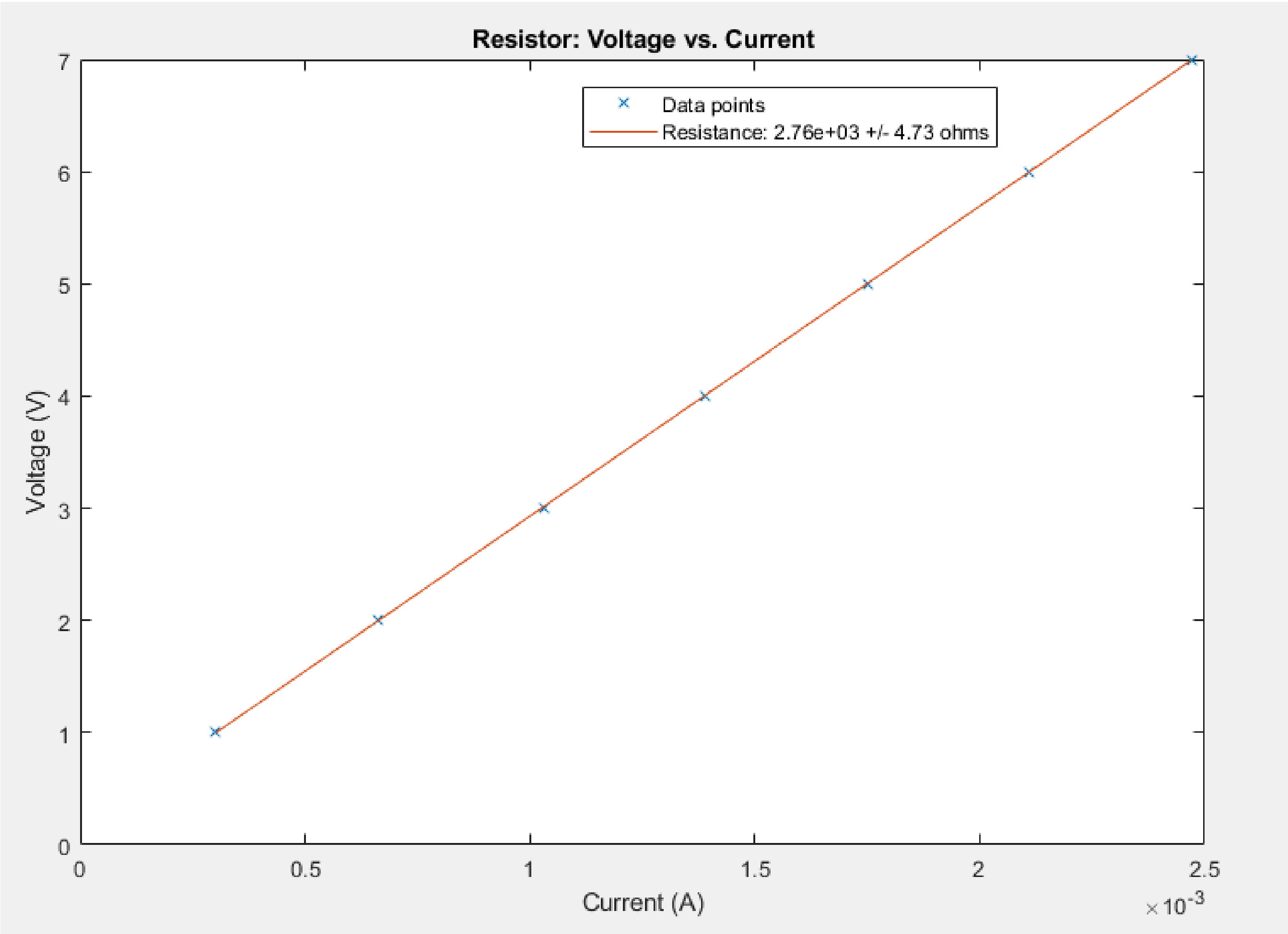
Current (A)	1V	2V	3V	4V	5V	6V	7V
Resistor	$0.30 \times 10^{-3}\mathrm{A}$	$0.66 \times 10^{-3}\mathrm{A}$	$1.03 \times 10^{-3}\mathrm{A}$	$1.39 \times 10^{-3}\mathrm{A}$	$1.75 \times 10^{-3}\mathrm{A}$	$2.11 \times 10^{-3}\mathrm{A}$	$2.47 \times 10^{-3}\mathrm{A}$
Inductor	$1.40 \times 10^{-3}\mathrm{A}$	$2.82 \times 10^{-3}\mathrm{A}$	$4.25 \times 10^{-3}\mathrm{A}$	$5.67 \times 10^{-3}\mathrm{A}$	$7.10 \times 10^{-3}\mathrm{A}$	$8.52 \times 10^{-3}\mathrm{A}$	$9.74 \times 10^{-3}\mathrm{A}$
Capacitor	$0.09 \times 10^{-3}\mathrm{A}$	$0.22 \times 10^{-3}\mathrm{A}$	$0.35 \times 10^{-3}\mathrm{A}$	$0.48 \times 10^{-3}\mathrm{A}$	$0.61 \times 10^{-3}\mathrm{A}$	$0.75 \times 10^{-3}\mathrm{A}$	$0.88 \times 10^{-3}\mathrm{A}$
RLC	$0.09 \times 10^{-3}\mathrm{A}$	$0.22 \times 10^{-3}\mathrm{A}$	$0.35 \times 10^{-3}\mathrm{A}$	$0.49 \times 10^{-3}\mathrm{A}$	$0.62 \times 10^{-3}\mathrm{A}$	$0.76 \times 10^{-3}\mathrm{A}$	$0.90 \times 10^{-3}\mathrm{A}$

Resonance

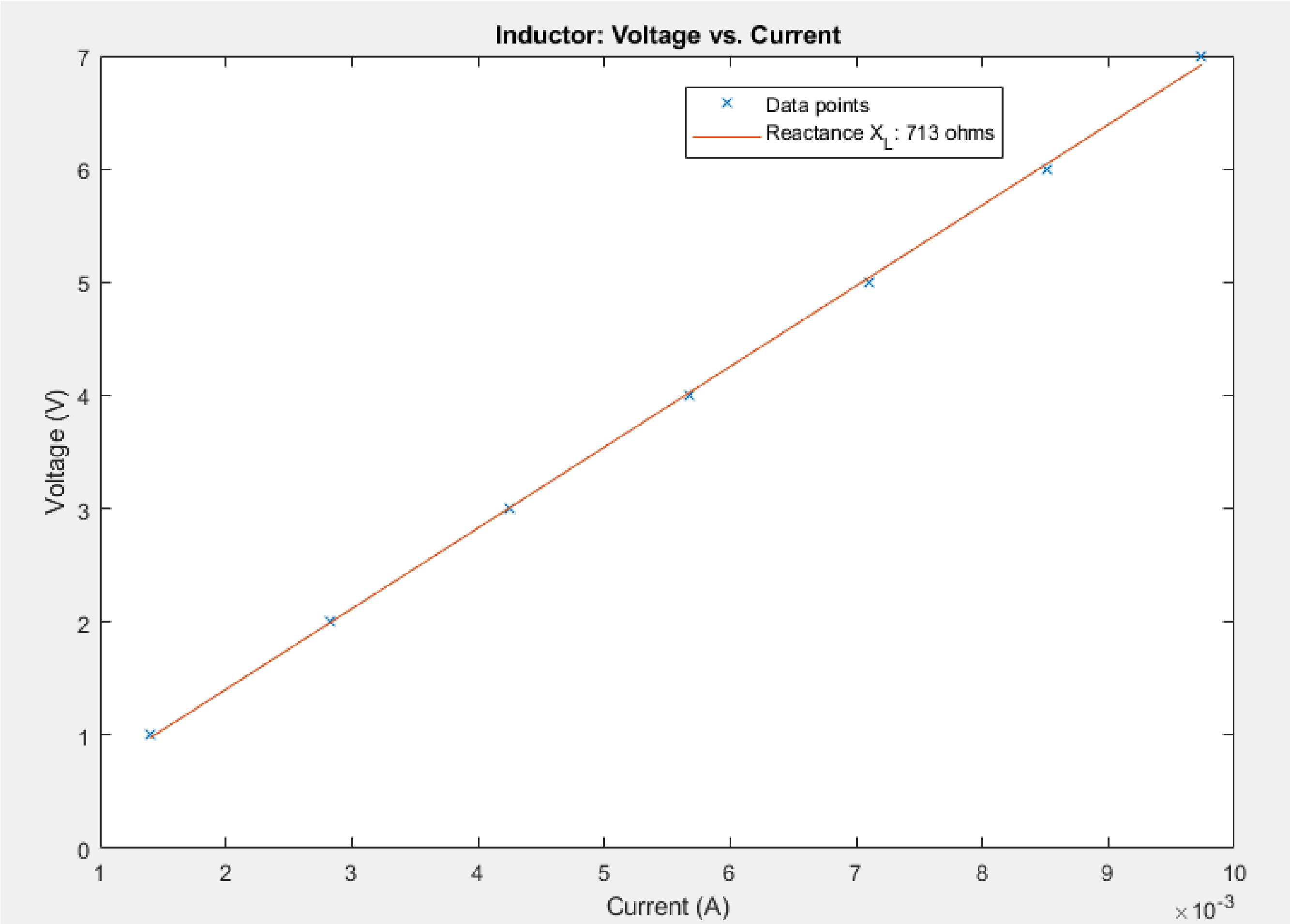
Maximum current: $1.58 \times 10^{-3}\mathrm{A}$
Resonance frequency $f = 4000\mathrm{Hz}$

Calculations and plots

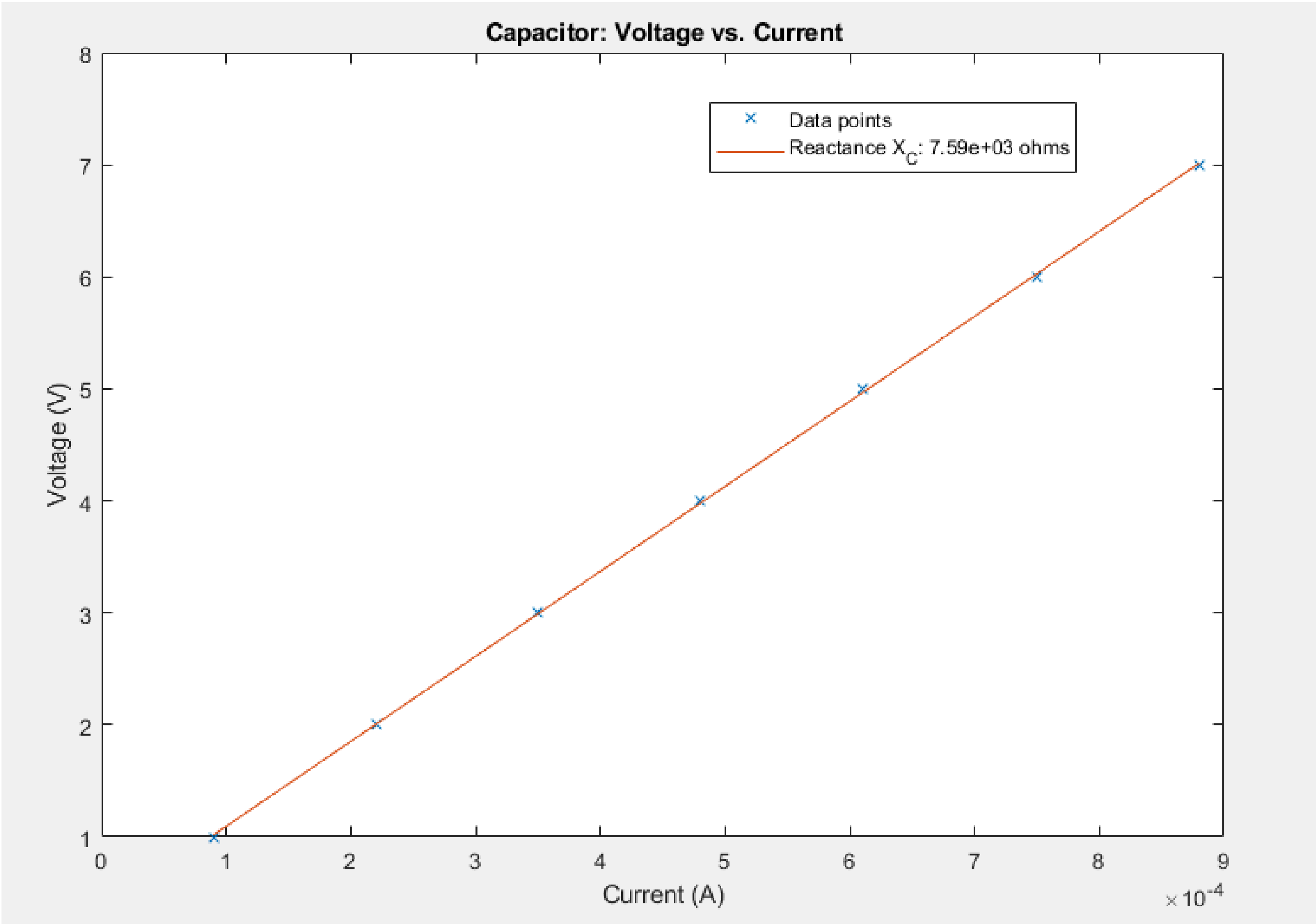
$R = 2.76 \times 10^3 \Omega, \sigma_R = 4.73\Omega$



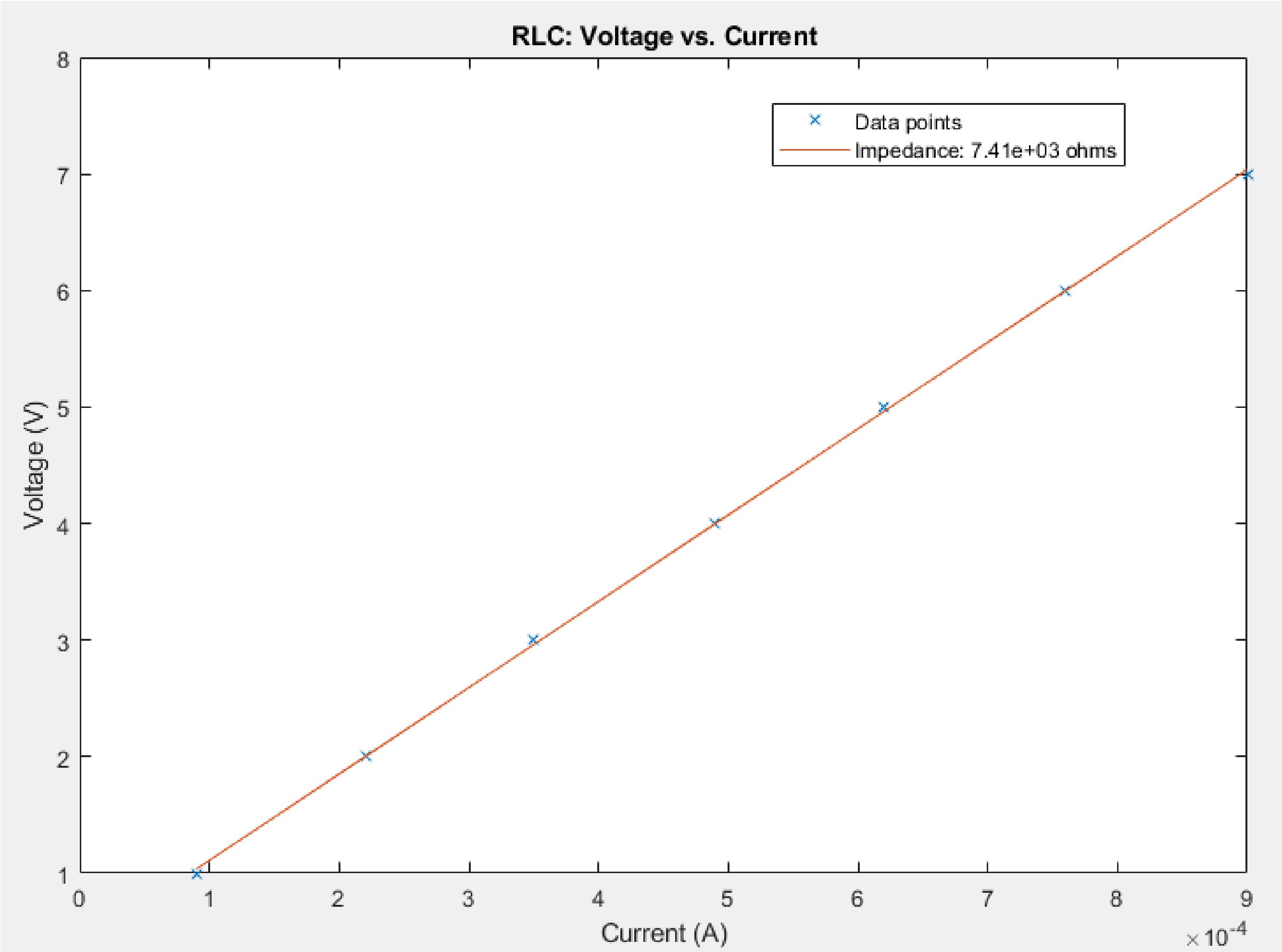
$X_L = 713\Omega, L = 0.110\text{H}$



$X_C = 7.59 \times 10^3 \Omega, C = 2.10 \times 10^{-8} F$



$Z_{exp} = 7.406 \times 10^3 \Omega$



$Z_{calc} = 7.409 \times 10^3 \Omega,$
$\Delta Z = 3\Omega,$
$\%$ error : 0.0405%

$f_{calc} = 3310\text{Hz},$
$\Delta f = 690\text{Hz},$
$\%$ error : 18.9%

Questions

1. The given values $R = 2700\Omega$, $L \approx 0.106\ \mathrm{H\ at\ 1000Hz}$, and $C \approx 0.02\mu F$ compare to the experimental values of $R = 2.76 \times 10^3\Omega$, $L = 0.110\ \mathrm{H\ at\ 1000Hz}$, and $C = 0.0210\mu F$. Therefore, the values do closely agree.
2. The calculated percent error using correct significant figures is zero; taking a leap and estimating beyond the accuracy of our calculations, the percent error using the next decimal place is still only 0.0405%. Therefore, the value Z_{exp} of the total impedance of the experimental circuit agrees with the value Z_{calc} of the calculated impedance using individual values R, L, and C.

Data sheet + Quiz

Answers

(Questions 1 – 4)

Quiz:

$X_L = 2\pi f L$

$X_c = \frac{1}{2\pi f C}$

$f_R = \frac{1}{2\pi\sqrt{LC}}$

$f = 2000\ \mathrm{Hz}$

$X_L = 2700\ \Omega$

$X_c = 1400\ \Omega$ →

$\frac{2700\Omega}{2000\mathrm{Hz}\cdot 2\pi} = L = 0.22$

$\frac{1}{1400\Omega \cdot 2000\mathrm{Hz}\cdot 2\pi} = C = 5.7\times 10^{-8} F$

$f_R = \frac{1}{2\pi\sqrt{0.22\cdot 5.7\times 10^{-8}}}$

$\boxed{\approx 1400\ \mathrm{Hz}}$

Bonus:

$\tan\phi = \frac{X_L - X_c}{R}$

At resonance freq.: $X_L = X_c$ →

$\tan\phi = 0$

$\phi = \tan^{-1}(0) = \boxed{0^\circ}$

8.6 Data sheet

Name: David McNeary	Date: 10/26/21	Instructor's initials:
Partner: Glendy Lara	Group No:	

Procedure and Data

1. Record the values of:

R (Ω)	Internal Resistance of Inductor (Ω)	C (F)
2.728 K Ω	136.7 Ω	21.45 nF

2. Record the current for the 4 cases at 1 kHz:

Current (A)	1V	2V	3V	4V	5V	6V	7V
Resistor	0.30mA	0.66mA	1.03mA	1.39mA	1.75mA	2.11mA	2.47mA
Inductor	1.40mA	2.82mA	4.25mA	5.67mA	7.10mA	8.52mA	9.74mA
Capacitor	0.09mA	0.22mA	035mA	0.48mA	0.61mA	0.75mA	0.88mA
RLC	0.09mA	0.22mA	0.35mA	0.49mA	0.62mA	0.76mA	0.90mA

3. Resonance. Set the voltage to 5 V. Vary the frequency until the current is maximum.

Maximum current=	1.58mA	Resonance Frequency $f =$	4000 Hz

Calculation

1. Plot voltage vs. current for resistor. From the slope determine the resistance R.

$R =$	$2.76 \times 10^3\ \Omega$	$\sigma_R =$	~~[illegible]~~ Ω ← 4.73 Ω

2. Plot voltage vs. current for inductor. From the slope determine the reactance X_L.

$X_L =$	713 Ω	$L =$	0.110 H	$\sigma_L =$	

3. Plot voltage vs. current for capacitor. From the slope determine the reactance X_C.

$X_C =$	$7.59 \times 10^3\ \Omega$	$C =$	2.10×10^{-8} F	$\sigma_C =$	

4. Plot voltage vs. current for RLC. From the slope determine the resistance Z.

$Z_{exp} =$	$7.406 \times 10^3\ \Omega$	$\sigma_Z =$	

Calculate Z using equation 8.19.

$Z_{calc} =$	$7.409 \times 10^3\ \Omega$	$\Delta Z =$	3 Ω	% error	0.0405%

Calculate the phase angle $\phi =$ 5.09 rad

5. Calculate resonance frequency using eqn 8.21 and compare with the measured value.

$f_{calc} =$	3310 Hz	$\Delta f =$	690 Hz	% error	18.9%