AHC Copy.
Sign and return before first experiment.

Electrical Engineering Laboratory
Allan Hancock College

LABORATORY SAFETY RULES

1. Arrive to your laboratory section on time. Instructions on the experiment and pertinent safety issues are discussed during the first few minutes of lab.
2. No horseplay or running will be tolerated in the laboratory.
3. No bare feet or open sandals are permitted while working in the laboratory.
4. Food and beverages are not allowed in the laboratory.
5. Never energize a circuit or piece of equipment without complete knowledge of its purpose and the resulting actions.
6. Do not energize any equipment without first observing that no one is in a position to be injured by your actions.
7. Examine carefully all line cords and test leads before using them. Never plug in an AC power cord that is frayed or has a loose or otherwise defective plug.
8. Report all defective or questionable tools and equipment to the instructor.
9. Rings, watches and other metal jewelry are electrical conductors. They may come in contact with live circuits and cause serious shocks or burns. Remove these items while working in the lab.
10. Avoid contact with any voltage source. Turn off the power before working on a circuit. Voltages as low as 30 volts have been fatal!
11. Do not make circuit connections by hand while circuits are energized. This is especially dangerous with high current circuits.
12. Never work in the laboratory alone.
13. Wear safety glasses, gloves and protective clothing when required.
14. Report all injuries, no matter how slight, to your instructor.
15. Keep your work area neat and clean. At the end of each lab session, return all leads, wires, components, equipment, etc., to where you found them. Power off all equipment.
16. Make sure your equipment is placed in a secure and stable position on the workbench.
17. Know the locations of the fire extinguishers, first aid kits, and emergency AC power shut off switches. Be sure to know how to use these items in case of an emergency.
18. When working with exposed 120-volt AC power in your circuit, have the instructor check your wiring before applying power.
19. Many precautions are required when soldering. Be sure you have detailed instruction in this area before you do any soldering in the laboratory.
20. Chemicals located in the laboratory can present a health hazard if proper safety precautions are not observed. Get approval from your instructor before using any chemicals.
21. Keep all exterior exit doors and aisles clear of any obstructions.

I (print name) ______________________________, have read, understand, and agree to follow the above mentioned safety rules, and any other directions given to me in writing or verbally by my instructor, or any other Allan Hancock Engineering or Electronics instructor.

Signed: ____ Date: ____________________

Program Copy. Sign and return **before** first experiment.

Student Copy.
Keep in Lab Manual.

Electrical Engineering Laboratory
Allan Hancock College

LABORATORY SAFETY RULES

1. Arrive to your laboratory section on time. Instructions on the experiment and pertinent safety issues are discussed during the first few minutes of lab.
2. No horseplay or running will be tolerated in the laboratory.
3. No bare feet or open sandals are permitted while working in the laboratory.
4. Food and beverages are not allowed in the laboratory.
5. Never energize a circuit or piece of equipment without complete knowledge of its purpose and the resulting actions.
6. Do not energize any equipment without first observing that no one is in a position to be injured by your actions.
7. Examine carefully all line cords and test leads before using them. Never plug in an AC power cord that is frayed or has a loose or otherwise defective plug.
8. Report all defective or questionable tools and equipment to the instructor.
9. Rings, watches and other metal jewelry are electrical conductors. They may come in contact with live circuits and cause serious shocks or burns. Remove these items while working in the lab.
10. Avoid contact with any voltage source. Turn off the power before working on a circuit. Voltages as low as 30 volts have been fatal!
11. Do not make circuit connections by hand while circuits are energized. This is especially dangerous with high current circuits.
12. Never work in the laboratory alone.
13. Wear safety glasses, gloves and protective clothing when required.
14. Report all injuries, no matter how slight, to your instructor.
15. Keep your work area neat and clean. At the end of each lab session, return all leads, wires, components, equipment, etc., to where you found them. Power off all equipment.
16. Make sure your equipment is placed in a secure and stable position on the workbench.
17. Know the locations of the fire extinguishers, first aid kits, and emergency AC power shut off switches. Be sure to know how to use these items in case of an emergency.
18. When working with exposed 120-volt AC power in your circuit, have the instructor check your wiring before applying power.
19. Many precautions are required when soldering. Be sure you have detailed instruction in this area before you do any soldering in the laboratory.
20. Chemicals located in the laboratory can present a health hazard if proper safety precautions are not observed. Get approval from your instructor before using any chemicals.
21. Keep all exterior exit doors and aisles clear of any obstructions.

I (print name) _______________________________, have read, understand, and agree to follow the above mentioned safety rules, and any other directions given to me in writing or verbally by my instructor, or any other Allan Hancock Engineering or Electronics instructor.

Signed: ____ Date:___________________

Student Copy. Keep in Lab Manual.

DATA SHEET, pg. 1/2 **Expt. #1 Ohm's Law, Resistance**	Name
	Lab Partner

Table 1-1 Direct Measurement of Resistor R_x (Step 2). *Do not forget to include units.*

Nominal Value	**470 Ω**	**2.7 kΩ**	**4.7 kΩ**
Measured Value			
%Difference with respect to (w.r.t.) *Nominal Value*			

Table 1-2 Calculated and Measured Current through 4.7 kΩ resistor.

Instructor:

Step #. Current	**Nominal Voltage (V)**	**Measured Voltage (V)**	**Resistance**	**Current (mA)**	**Calculated Resistance (kΩ)**
7a. Calculated Current	6.00 V		Nominal, 4.7 kΩ	calc	
7b. Calculated Current	6.00 V		Measured, from ***Table 1-1***	calc	
9. Measured Current	6.00 V			meas	
13. Measured Current	12.00 V			meas	

Are the current values in Steps 7a and 7b within 5% of each other? YES NO (circle one)

Are the current values in Steps 7a and 9 within 5% of each other? YES NO (circle one)

Table 1-3 Voltage and Current Measurements: 470 Ω and 2.7 kΩ. *Include units*.

Nominal Voltage across R_x (V)	**Measured Voltage and Current**			
	470-Ω resistor		**2.7-kΩ resistor**	
	v_x **(V)**	***i*** **( )**	v_x **(V)**	***i*** **( )**
0.0*	0.00000	0.00000	0.00000	0.00000
2.0				
4.0				
6.0				
8.0				
10.0				
12.0				
Calculated Resistance at 12.0 V	R_x =		R_x =	

* Include the point (0,0) in the graphs.

DATA SHEET, pg. 2/2 **Expt. #1 Ohm's Law, Resistance**	Name Lab Partner

Table 1-4 Measured Voltages and Calculated Resistances for Single Voltmeter Method.

Measured value of known resistor (nominally 2.0 kΩ), R_1 = _______________.

Nominal Value, of "Unknown" R_x	v_1: Voltage across known resistor R_1 (V)	v_x: Voltage across "unknown" resistor R_x (V)	Calculated R_x *Include units.*
470 Ω			
2.7 kΩ			
4.7 kΩ			

Summary

Table 1-5 Comparison of Resistance Values for Three Methods. *Include units*.

	Direct Measurement	**Calculated from Measurements**			
Nominal Value	**Ohmmeter**	**Voltmeter-Ammeter Method (at v = 12.0 V)**		**Single-Voltmeter Method**	
R_x	R_x	**R_x Value**	**% Error***	**R_x Value**	**% Error***
470 Ω					
2.7 kΩ					
4.7 kΩ					

* %Error with respect to ***directly measured value*** (or *actual value*)

$$\%\text{Error} = \frac{[\text{calculated}] - [\text{directly measured}]}{[\text{directly measured}]} \times 100\%$$

Instructor Initial:

DATA SHEET, pg. 1/3	Name
Expt. #2a 3-Resistor Series Circuit	Lab Partner

Table 2-1 Resistances, Voltages and Currents for 3-Resistor Series Circuit. *Do not forget units.*

subscripts: *m* : measured; *c* : calculated from measured values

Instructor:

Nominal Resistance	Measured Resistance	Measured Voltage (V)	Calculated Current (mA) (use measured v & R)	Measured Current (mA)
$R_1 = 680\ \Omega$		$v_{1,m} =$	$i_{1,c} =$	$i_{1,m} =$
$R_2 = 1.0\ k\Omega$		$v_{2,m} =$	$i_{2,c} =$	$i_{2,m} =$
$R_3 = 3.0\ k\Omega$		$v_{3,m} =$	$i_{3,c} =$	$i_{3,m} =$
Calculated Equivalent Resistance (from measured resistances R_i) $R_{s,c} = \Sigma R_k =$		**Calculated Total Voltage** (from measurements $v_{k,m}$) $(\Sigma v_k)_c =$		
Measured Equivalent Resistance $R_{s,m} =$		**Measured Total Voltage** (Source Voltage) $v_s = V_{ab,m} =$		

Table 2-2 Equivalent Resistance and Voltage Drop across each Resistor. *Do not forget units.*

Quantity	Pre-lab Calculations (use nominal values)	In-Lab Calculations (ΣR_i)	Direct Measurements	% Difference* (w.r.t. nominal)
Equivalent Resistance				
Voltage, v_1				
Voltage, v_2				
Voltage, v_3				

* With respect to nominal value. $(\%\text{ difference w.r.t. nominal}) = \frac{(\text{measured value}) - (\text{nominal value})}{(\text{nominal value})} \times 100\%$

Table 2-3 Power Supplied or Dissipated by Components

(for *Calculated Power*, use the sign convention: "–" if power is supplied, "+" if it is absorbed)

Component	Measured Resistance (Ω)	Measured Voltage (V)	Measured Current (mA)	Calculated Power (mW)
Voltage Source				
R_1				
R_2				
R_3				

DATA SHEET, pg. 2/3	Name
Expt. #2b 3-Resistor Parallel Circuit	Lab Partner

Table 2-4 Resistances, Voltages and Currents for 3-Resistor Parallel Circuit. Do not forget units.

Nominal Resistance	**Measured Resistance**	**Measured Current (mA)**	**Calculated Voltage (V)** (use measured i & R)	**Measured Voltage (V)**
$R_1 = 680\ \Omega$		$i_{1,m} =$	$v_{1,c} =$	$v_{1,m} =$
$R_2 = 1.0\ k\Omega$		$i_{2,m} =$	$v_{2,c} =$	$v_{2,m} =$
$R_3 = 3.0\ k\Omega$		$i_{3,m} =$	$v_{3,c} =$	$v_{3,m} =$
Calculated Equivalent Resistance (from measured resistances R_i) $R_{p,c} =$		**Calculated Total Current** (from measurements $i_{k,m}$) $(\Sigma i_k)_c =$		$V_{cd,m} =$
Measured Equivalent Resistance $R_{p,m} =$		**Measured Total Current** (Source Current) $i_m =$		

Table 2-5 Equivalent Resistance and Current through each Resistor.

Quantity	**Pre-lab Calculations** (use nominal values)	**In-Lab Calculations** ($R_{p,c}$)	**Direct Measurements**	**% Difference*** (w.r.t. nominal)
Equivalent Resistance				
Total Current i				
Current, i_1				
Current, i_2				
Current, i_3				

* With respect to nominal value. $(\text{\% difference w.r.t. nominal}) = \dfrac{(\text{measured value}) - (\text{nominal value})}{(\text{nominal value})} \times 100\%$

Table 2-6 Power Supplied or Dissipated by Components
(for *Calculated Power*, use the sign convention: "–" if power is supplied, "+" if it is absorbed)

Component	**Measured Resistance (Ω)**	**Measured Voltage (V)**	**Measured Current (mA)**	**Calculated Power (mW)**
Voltage Source				
R_1				
R_2				
R_3				

DATA SHEET, pg. 3/3	Name
Expt. #2c 2-Resistor Parallel Circuit	Lab Partner

Table 2-7 Resistances, Voltages and Currents for 2-Resistor Parallel Circuit.

Nominal Resistance	**Measured Resistance**	**Measured Current (mA)**	**Calculated Voltage (V)** (use measured i & R)	**Measured Voltage (V)**
$R_1 = 680\ \Omega$		$i_{1,m} =$	$v_{1,c} =$	$v_{1,m} =$
$R_2 = 1.0\ k\Omega$		$i_{2,m} =$	$v_{2,c} =$	$v_{2,m} =$
Calculated Equivalent Resistance (from measured resistances R_i) $R_{p,c} =$		**Calculated Total Current** (from measurements $i_{k,m}$) $(\Sigma i_k)_c =$		$V_{ef,m} =$
Measured Equivalent Resistance $R_{p,m} =$		**Measured Total Current** (Source Current) $i_m =$		

This page intentionally left blank.

DATA SHEET, pg. 1/2	Name
Expt. #3 Superposition	Lab Partner

Table 3-1 Resistor Values.

Nominal Value	Measured Resistance (kΩ)	%Difference (with respect to nominal)	Within Tolerance?
1.0 kΩ			
2.0 kΩ			
2.2 kΩ			
3.0 kΩ			

Table 3-2 Measured Voltage V_x and Current i_x for Case I: $\boldsymbol{v_1}$ **= +16.0 V,** $\boldsymbol{v_2}$ **= +12.0 V**.

Case	Voltage Source	Measured Supply Voltage (V)	Measured Voltage (V)	Measured Current (mA)
Ia	v_1 = 16.0 V; v_2 = 0.0 V	v_1 =	$V_{x'}$ =	$i_{x'}$ =
Ib	v_1 = 0.0 V; v_2 = 12.0 V	v_2 =	$V_{x''}$ =	$i_{x''}$ =
Ia + Ib	**Sum of individual measurements** (*calculate*)		ΣV_{xk} =	Σi_{xk} =
Ic	**Supply voltages acting together** v_1 = 16.0 V; v_2 = 12.0 V	v_1 = v_2 =	V_x =	i_x =

Table 3-3 Measured Voltage V_x and Current i_x for Case II: $\boldsymbol{v_1}$ **= 8.0 V,** $\boldsymbol{v_2}$ **= –12.0 V**.

Case	Voltage Source	Measured Supply Voltage (V)	Measured Voltage (V)	Measured Current (mA)
IIa	v_1 = 8.0 V; v_2 = 0.0 V	v_1 =	$V_{x'}$ =	$i_{x'}$ =
IIb	v_1 = 0.0 V; v_2 = –12.0 V	v_2 =	$V_{x''}$ =	$i_{x''}$ =
IIa + IIb	**Sum of individual measurements** (*calculate*)		ΣV_{xk} =	Σi_{xk} =
IIc	**Supply voltages acting together** v_1 = 8.0 V; v_2 = –12.0 V	v_1 = v_2 =	V_x =	i_x =

DATA SHEET, pg. 2/2	Name
Expt. #3 Superposition	Lab Partner

Table 3-4 Circuit Resistance Measurements.

Resistance	Step	Measured Resistance (Ω)
Resistance seen by v_1 (in v_1-only circuit)	**7**	
Resistance seen by v_2 (in v_2-only circuit)	**12**	
Resistance measured across the 2.2-kΩ resistor	**19**	

DATA SHEET, pg. 1/2 **Expt. #4 Equivalent Circuits**	Name
	Lab Partner

Table 4-1 Resistance Values.

Nominal Value	Measured Resistance (kΩ)	% Difference (%) (with respect to nominal)	Is it within Tolerance?
1.0 kΩ			
2.0 kΩ			
3.0 kΩ			
10 kΩ pot (outer terminals)			

Table 4-2 Circuit Measurements. Source voltage: v_s = ________________.

R_L	Load Resistor R_L	Voltage across 2 kΩ V_{2k}	Load Voltage V_L	Source Current i_s	Source Power P_s	Load Power P_L	Efficiency
nominal	measured	measured	measured	V_{2k}/R_{2k}	$v_s \times i_s$	$\frac{V_L^2}{R_L}$	$\frac{P_L}{P_s} \times 100\%$
Units: Ω	Ω						%
200							
300							
500							
700							
1.0k							
2.0k							
3.0k							
5.0k							
7.0k							
10k							

*Remember to take four additional measurements near and around the estimated value of R_L that gives the greatest P_L; these four measurements should give a better estimate of the R_L that gives the maximum load transfer. Do not select values that are too close together. As more measurements are taken, if possible, revise the approximation of R_L for maximum power transfer.

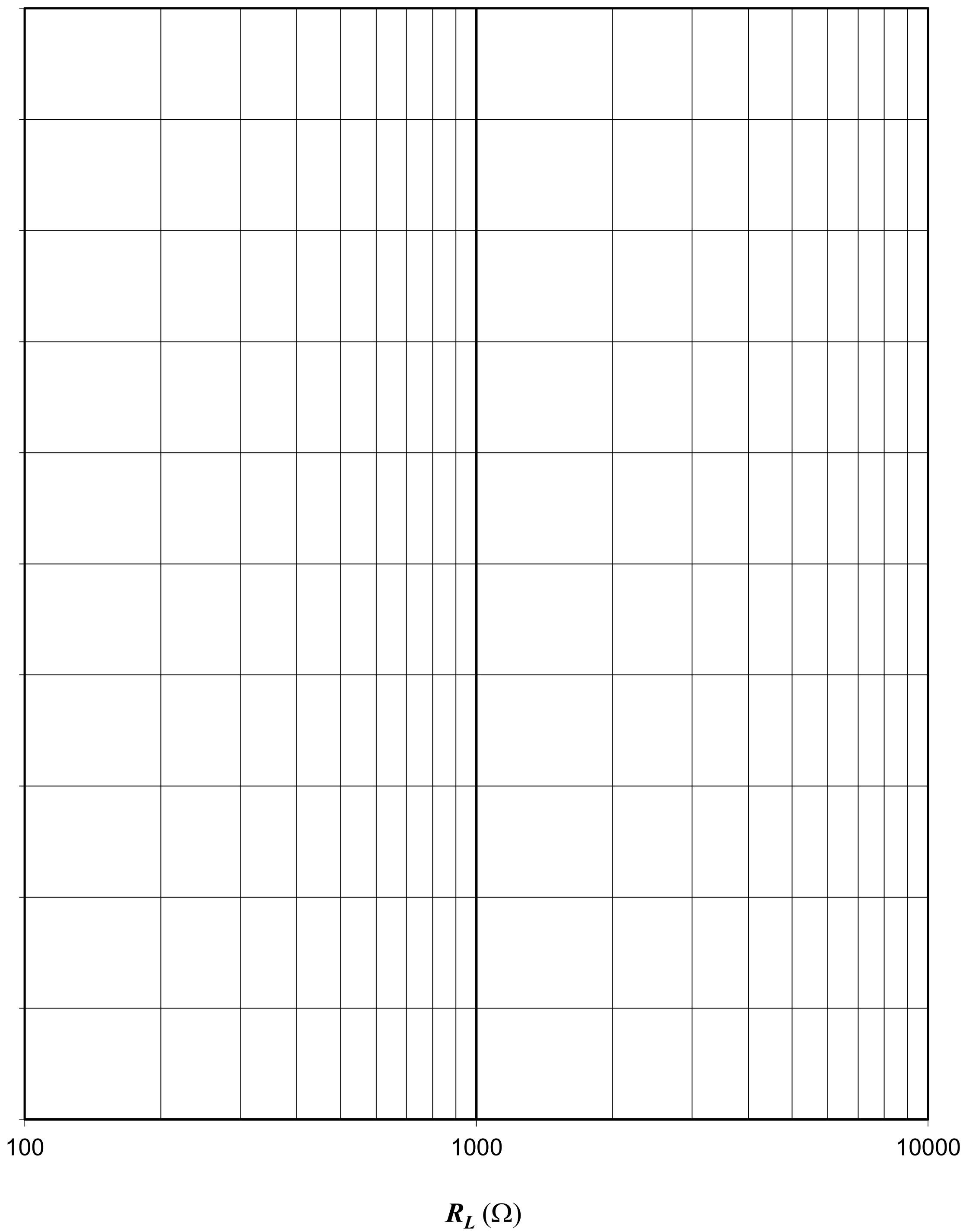
DATA SHEET, pg. 2/2 Expt. #4 Equivalent Circuits	Name
	Lab Partner

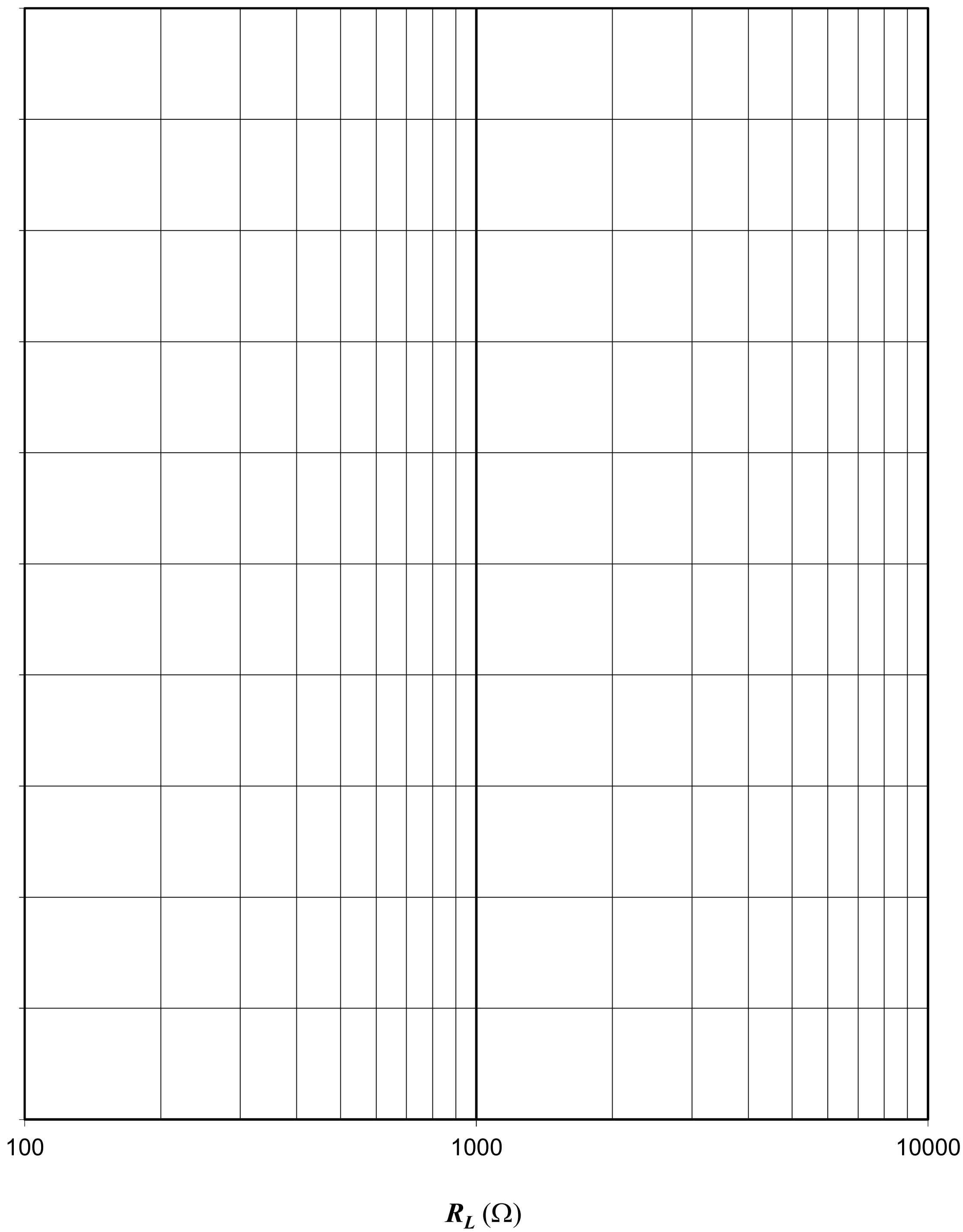
Table 4-3 Thevenin Equivalent.

	CALCULATIONS		DIRECT MEASUREMENTS [Steps 15-17]	Calculated R_{Th} from *measured* V_{Th} and measured i_{sc} [Step 19]
	Nominal Values [Step 13]	Measured Values [Step 14]		
V_{Th}	$V_{Th,\mathrm{n}}$	$V_{Th,\mathrm{c}}$	$V_{Th,\mathrm{m}}$	$R_{Th,\mathrm{exp}} = V_{Th,\mathrm{m}} / i_{sc,\mathrm{m}} =$
i_{sc}			$i_{sc,\mathrm{m}}$	Does the calculated $R_{Th,\mathrm{exp}}$ (above) agree with the directly-measured $R_{Th,\mathrm{m}}$?
R_{Th}	$R_{Th,\mathrm{n}}$	$R_{Th,\mathrm{c}}$	$R_{Th,\mathrm{m}}$	

Table 4-4 Thevenin Circuit Measurements. V_{Th} = _______________; R_{Th} = _______________.

R_L	Load Resistor R_L	Load Voltage V_L	Source Current i_s	Source Power P_s	Load Power P_L	Efficiency
nominal	measured	measured	$\frac{V_{Th}}{R_{Th}+R_L} = \frac{V_L}{R_L}$	$V_{Th} \times i_s$	$\frac{V_L^2}{R_L}$	$\frac{P_L}{P_s} \times 100\%$
Units: Ω						%
200						
300						
500						
700						
1.0k						
2.0k						
3.0k						
5.0k						
7.0k						
10k						
R_{Th} =						


100
1000
10000
R_L (Ω)


100
1000
10000
R_L (Ω)

DATA SHEET, pg. 1/2	Name
Expt. #5 Op Amps	Lab Partner

Table 5-1 Resistance Values for Op-Amp Circuit

Nominal Value	Measured Resistance (kΩ)	% Difference (w.r.t. nominal)	Is Resistance within Tolerance?
R_1 = 10 kΩ			
R_2 = 33 kΩ			

Table 5-2 Op-Amp Circuit Amplification v_i **= 0.5 V DC**.

Supply Voltages (measured): V^+=________V; V^-=________V.

	Pre-Lab Calculations (predictions) (using nominal values)		In-Lab Measurements			
	Output Voltage V_o (V)	Amplification V_o/v_i	Input Voltage v_i (V)	Output Voltage V_o (V)	Amplification V_o/v_i	%Difference in Amplification (w.r.t. Nominal)
Inverting Op-Amp Circuit						
Non-Inverting Op-Amp Circuit						
Buffer						

Table 5-3 Input Voltage – Output Voltage Measurements (record data down left, then right column)

5-3a **Inverting Op-Amp Circuit**			
V^+=__________V; V^-=__________V			
v_i (V)	V_o (V)	v_i (V)	V_o (V)
0.0000	0.000		

5-3b **Non-Inverting Op-Amp Circuit**			
V^+=__________V; V^-=__________V			
v_i (V)	V_o (V)	v_i (V)	V_o (V)
0.000	0.000		

DATA SHEET, pg. 2/2 **Expt. #5 Op Amps**	Name
	Lab Partner

Table 5-4 Saturation Voltages, Estimated from *In-lab Hand-plots* of V_o vs. v_i.

Measured Supply Voltages: V^+=__________V; V^-=__________V.

	Input Voltage $V_{i,sat}$ **(V)**	**Output Voltage** $V_{o,sat}$ **(V)**
Inverting Op-Amp Circuit		
Non-Inverting Op-Amp Circuit		

Table 5-5 Output Voltage (Load Voltage) for Various Load Resistors for Inverting Op-Amp Circuit. v_i **= 1.0 V DC**.

R_L	**470 Ω**	**2.0 kΩ**	**4.7 kΩ**
Measured Resistance (kΩ)			
Measured Input Voltage, v_i **(V)**			
Output Voltage = Load Voltage $V_o = V_L$ **(V)**			
Load Current, i_L **(mA)**			

DATA SHEET, pg. 1/4 **Expt. #8: Oscilloscope**	Name Lab Partner

Table 8-1 PROBE ADJUST and HUMAN ANTENNA Signals.

	Shape of Signal	**Peak-to-Peak Voltage, $V_{p\text{-}p}$ (V)**	**Measured Period, *T* ( )**	**Calculated Frequency, *f* (Hz)**	**Replicated Probe Adjust Signal?**
Probe Adjust					Instructor Init.:
Human Antenna					

Table 8-2a Sine wave with DC Offset: $v(t) = 2.0 + 3.0\cos[2\pi(500)t]$ V .

Step	***Question***	***Answer***	
12	What is $v(t)_{max}$? What is $v(t)_{min}$?	V_{max}:	V_{min}:
15	For 2.0 V/DIV, how many divisions equal 1.0 volt?		
16	For 0.5 mSEC/DIV, how many divisions equal 1.0 second?		
18	**AC Coupling measurement**. How many divisions tall is the signal (from top to bottom)? How many volts tall is it (top to bottom)?	Divisions:	Volts:
19	**AC Coupling measurement**. What is the period of the signal in divisions? What is the period *T* in milliseconds?	Divisions:	*T* (msec):

Step 21 Instructor Initial:

DATA SHEET, pg. 2/4 **Expt. #8: Oscilloscope**	Name Lab Partner

Table 8-2b Sine wave with DC Offset: $v(t) = 2.0 + 3.0\cos[2\pi(500)t]$ V .

Step	***Question***	***Answer***	
<u>Each</u> step below (#23, 25) should start at <u>2.0 V/DIV</u> and <u>0.5 mSEC/DIV</u>. **<u>CW</u>: Clockwise, <u>CCW</u>: counter-clockwise.**			
23	What happens to the appearance of the signal when the VOLT/DIV knob is turned 1 click <u>CW</u>? What is the new VOLT/DIV setting?		New VOLTS/DIV
25	What happens to the appearance of the signal when the VOLT/DIV knob is turned 1 click <u>CCW</u>? What is the new VOLT/DIV setting?		New VOLTS/DIV
<u>Each</u> step below (#30, 32) should now start at <u>1.0 V/DIV</u> and <u>0.5 mSEC/DIV</u>. **Note the <u>new</u> volts/div setting.** **<u>CW</u>: Clockwise, <u>CCW</u>: counter-clockwise.**			
30	What happens to the appearance of the signal when the SEC/DIV knob is turned 1 click <u>CW</u>? What is the new SEC/DIV setting?		New SEC/DIV
32	What happens to the appearance of the signal when the SEC/DIV knob is turned 1 click <u>CCW</u>? What is the new SEC/DIV setting?		New SEC/DIV

DATA SHEET, pg. 3/4 **Expt. #8: Oscilloscope**	Name Lab Partner

Table 8-3 Voltage Measurement Exploration: $v(t) = 2.0 + 3.0\cos\left[2\pi(500)t\right]$ V .

Step	***Question***	***Answer***
38: DC Coupling		
39	VOLTMETER/DC (V)	
40	VOLTMETER/+PEAK (V)	
41	VOLTMETER/–PEAK (V)	
42	VOLTMETER/PEAK-PEAK (V)	
43	What is the scope message when the signal is zoomed so it no longer fits on the display?	
44: AC Coupling (repeat above measurements) – record displayed values in AC mode-only.		
39	VOLTMETER/DC (V)	
40	VOLTMETER/+PEAK (V)	
41	VOLTMETER/–PEAK (V)	
42	VOLTMETER/PEAK-PEAK (V)	

Explain the difference between DC and AC coupling measurements in words – why are they different? Do the answers of ***Table 8-3*** make sense with regards to ***Equation 8.1***? Explain why or why not? (attach a separate sheet if necessary).

DATA SHEET, pg. 4/4	Name
Expt. #8: Oscilloscope	Lab Partner

Table 8-4 Time Measurement Exploration: $v(t) = 2.0 + 3.0\cos[2\pi(500)t]$ V .

Step	***Question***	***Answer***
COURSOR and COUNTER MEASUREMENTS. Use AC Coupling.		
52	Half-period cursor measurement, maximum to minimum.	
53	Half-period cursor measurement: intersection of waveform with printed horizontal line corresponding to ground (V = 0).	
54	Which measurement technique will give a more precise measurement, **Step 52** or **Step 53**. Explain why (think about the <u>best</u> way to determine where a point is).	
57	Phase Angle half-period cursor measurement.	
60	Scope frequency measurement of FG 900 Hz signal.	
60	*Calculated period* for 900 Hz (use frequency measured in **Step 60**).	
61	*Measured period* for 900 Hz signal. Does it agree with your calculation?	

DATA SHEET, pg. 1/3 **Expt. #9 R.M.S. Measurements**	Name
	Lab Partner

Table 9-1 Voltage and Frequency Measurements: **4.0 V_{pp}, 1.0 kHz sine wave**.

Measured source signal: V_{pp} = _________ V (on scope).

	Function Generator Display*	**Predicted Values** (pre-lab; nominal)	**Scope Measurement**	**DMM Measurement**	**% Difference in V_{rms}** (DMM w.r.t. pre-lab values)
V_{rms} (V)					
f **(Hz)**					
Period (msec)					

* Write "n/a" (*not applicable*) in this column if there is no display on the function generator.

Table 9-2 Voltage and Frequency Measurements: **3.0 V_{pp}, 500 Hz sine wave**.

Measured source signal: V_{pp} = _________ V.

	Function Generator Display*	**Predicted Values** (pre-lab; nominal)	**Scope Measurement**	**DMM Measurement**	**% Difference in V_{rms}** (DMM w.r.t. pre-lab values)
V_{rms} (V)					
f **(Hz)**					

* Write "n/a" (*not applicable*) in this column if there is no display on the function generator.

Table 9-3 Voltage and Frequency Measurements: **6.0 V_{pp}, 2.0 kHz square wave**.

Measured source signal: V_{pp} = _________ V.

	Function Generator Display*	**Predicted Values** (pre-lab; nominal)	**Scope Measurement**	**DMM Measurement**	**% Difference in V_{rms}** (DMM w.r.t. pre-lab values)
V_{rms} (V)					
f **(Hz)**					

* Write "n/a" (*not applicable*) in this column if there is no display on the function generator.

DATA SHEET, pg. 2/3	Name
Expt. #9 R.M.S. Measurements	Lab Partner

Table 9-4 Voltage and Frequency Measurements:
6.0 V_{pp}, 2.0 kHz square wave, +1.0 V DC Offset.

Measured source signal: V_{pp} = _________ V, V_{DC} = _________ V.

	Function Generator Display*	**Predicted Values** (pre-lab; nominal)	**Scope Measurement**	**DMM Measurement**	**% Difference in V_{rms}** (DMM w.r.t. pre-lab values)
V_{rms} **(V)**					
f **(Hz)**					

* Write "n/a" (*not applicable*) in this column if there is no display on the function generator.

Table 9-5 R.M.S. Current Calculation and Measurement:
9.0 V_{pp}, 200 Hz sine wave; 2.2 kΩ resistor.

Measured source signal: V_{pp} = _________ V.

	Calculated Value from Scope Reading	**DMM Measurement**	**% Difference** w.r.t. value calculated from scope measurement
i_{rms} **(mA)**			

DATA SHEET, pg. 3/3	Name
Expt. #9 R.M.S. Measurements	Lab Partner

Table 9-6 Oscilloscope Voltage Measurements:
9.0 V_{pp}, 200 Hz sine wave; 1.0 kΩ and 2.0 kΩ resistors in series.

Step	Reading	$V_{p\text{-}p}$ (V)	Remark
15	**Ch. 2** (probe across 2.0 kΩ, Ch. 1 not connected)		
16	**Ch. 2** (with Ch. 1 probe across 1.0 kΩ)		
18	**Ch. 1** (across both resistors)		
19	**Ch. 2** (across 2.0 kΩ)		
20	**Calculated Ch. 1 *minus* Ch. 2**		
21	**Measured Ch. 1 *minus* Ch. 2**		

Table 9-7 DMM V_{rms} Measurements:
9.0 V_{pp}, 200 Hz sine wave; 1.0 kΩ and 2.0 kΩ resistors in series.

Voltage	V_{rms} (V)	Does the distribution of V_{rms} between the 1.0 and 2.0 kΩ resistors agree with voltage division? Explain why the voltage distribution should or should not agree.
Measured across 1.0 kΩ		
Measured across 2.0 kΩ		
Sum of individual measurements (calculate)		
Measured across both resistors		
% Difference (sum of individual voltages w.r.t. direct measurement)		

This page intentionally left blank.

DATA SHEET, pg. 1/4 **Expt. #10 AC Circuits/Phasors**	Name
	Lab Partner

Table 10-1 Resistor, Capacitor and Inductor Values. *Include units.*

Element	**Measured Value**	**% Error** (w.r.t. nominal)
2.0 kΩ resistor	$R =$	
33 mH Inductor inductance and DC resistance DC is when $f = 0$ Hz	$R_L =$	n/a
	$L =$	
Large Inductor inductance and DC resistance	$R_L =$	n/a
	$L =$	n/a
0.1 μF Capacitor	$C =$	

Table 10-2 Voltage and Current Measurements, Calculation of Impedance and Inductance.

4.0 $V_{p\text{-}p}$, 400 Hz sine wave. *Include units.*

Measured source signal: V_{pp} = _________ V, f = _________ Hz.

	33 mH Inductor	**Large Inductor**
Predicted Magnitude of Total Impedance, $\lvert \mathbf{Z}_L \rvert$		
V_{rms} across inductor (measured)		
I_{rms} through inductor (measured)		
$\lvert \mathbf{Z}_L \rvert$, calculated from measured r.m.s. values		
% difference in $\lvert \mathbf{Z}_L \rvert$ with respect to predicted value		
L, calculated from measured r.m.s. values		
% difference in L w.r.t. directly measured value		

DATA SHEET, pg. 2/4	Name
Expt. #10 AC Circuits/Phasors	Lab Partner

Table 10-3 Calculated Impedance, Current, Voltage: RC Circuit, **10.0 $V_{p\text{-}p}$, 600 Hz sine wave.**
Nominal values: R = 2.0 kΩ, C = 0.1 μF
Assume the voltage source has zero phase: $\mathbf{V_S} = V_S\angle 0°$.

Quantity	**Value and Units**
$\mathbf{Z}_{total}$, *rectangular form* (calculated from measured values)	
$\mathbf{Z}_{total}$, *polar form* (calculated from measured values)	
Phasor Current, **I** (polar form, calculated from $\mathbf{V_S} = 5\angle 0°$ V and $\mathbf{Z}_{total}$)	
Phasor Voltage, $\mathbf{V_C}$ (polar form, calculated from **I** and $\mathbf{Z}_C$)	
Phasor Voltage, $\mathbf{V_R}$ (polar form, calculated from **I** and $\mathbf{Z}_R$)	

Table 10-4 Measured Voltages: RC Circuit, **10.0 $V_{p\text{-}p}$, 600 Hz sine wave.**
Assume the voltage source has zero phase: $\mathbf{V_S} = V_S\angle 0°$.

Measured source signal: V_{pp} = __________ V, f = __________ Hz.

Quantity	**Scope, V_p (V) (measured)**	**Scope, V_{rms} (V) (calculated)**	**DMM, V_{rms} (V) (measured)**
Source Voltage, V_S			
Capacitor Voltage, V_C			
Resistor Voltage, V_R			

Table 10-5 Measured Phase Angles: RC Circuit, **10.0 $V_{p\text{-}p}$, 600 Hz sine wave.**
Assume the voltage source has zero phase: $\mathbf{V_S} = V_S\angle 0°$.
Give angle as positive or negative, depending on if it leads or lags.

Quantity	**Value and Unit**
Capacitor Phase Angle, ϕ_C (measured, with respect to $\mathbf{V_S}$)	
Resistor Phase Angle, ϕ_R (measured, with respect to $\mathbf{V_S}$)	
Does $\mathbf{V_C}$ lead or lag $\mathbf{V_S}$?	
Does $\mathbf{V_R}$ lead or lag $\mathbf{V_S}$?	

DATA SHEET, pg. 3/4 **Expt. #10 AC Circuits/Phasors**	Name
	Lab Partner

Table 10-6 Calculated Impedance, Current, Voltage: RC Circuit, **10.0 $V_{p\text{-}p}$, 1.0 kHz sine wave.**
Nominal values: R = 2.0 kΩ, C = 0.1 μF
Assume the voltage source has zero phase: $\mathbf{V_S} = V_S\angle 0°$.

Quantity	**Value and Units**
$\mathbf{Z}_{total}$, *rectangular form* (calculated from measured values)	
$\mathbf{Z}_{total}$, *polar form* (calculated from measured values)	
Phasor Current, **I** (polar form, calculated from $\mathbf{V_S} = 5\angle 0°$ V and $\mathbf{Z}_{total}$)	
Phasor Voltage, $\mathbf{V_C}$ (polar form, calculated from **I** and $\mathbf{Z}_C$)	
Phasor Voltage, $\mathbf{V_R}$ (polar form, calculated from **I** and $\mathbf{Z}_R$)	

Table 10-7 Measured Voltages: RC Circuit, **10.0 $V_{p\text{-}p}$, 1.0 kHz sine wave.**
Assume the voltage source has zero phase: $\mathbf{V_S} = V_S\angle 0°$.

Measured source signal: V_{pp} = __________ V, f = __________ Hz.

Quantity	**Scope, V_p (V) (measured)**	**Scope, V_{rms} (V) (calculated)**	**DMM, V_{rms} (V) (measured)**
Source Voltage, V_S			
Capacitor Voltage, V_C			
Resistor Voltage, V_R			

Table 10-8 Measured Phase Angles: RC Circuit, **10.0 $V_{p\text{-}p}$, 1.0 kHz sine wave.**
Assume the voltage source has zero phase: $\mathbf{V_S} = V_S\angle 0°$.
Give angle as positive or negative, depending on if it leads or lags.

Quantity	**Value and Unit**
Capacitor Phase Angle, ϕ_C (measured, with respect to $\mathbf{V_S}$)	
Resistor Phase Angle, ϕ_R (measured, with respect to $\mathbf{V_S}$)	
Does $\mathbf{V_C}$ lead or lag $\mathbf{V_S}$?	
Does $\mathbf{V_R}$ lead or lag $\mathbf{V_S}$?	

DATA SHEET, pg. 4/4 **Expt. #10 AC Circuits/Phasors**	Name
	Lab Partner

Table 10-9 RC Circuit for Equal *Resistance* and *Reactance* **10.0 $V_{p\text{-}p}$, ? Hz sine wave.**

Nominal values: R = 2.0 kΩ, C = 0.1 μF

	Quantity and Unit
Calculated frequency $f = f_o$ for $R = \|X_C\|$	
Measured frequency f_o	
Source Voltage, $V_{S,rms}$ at f_o	
Capacitor Voltage, $V_{C,rms}$ at f_o	
Resistor Voltage, $V_{R,rms}$ at f_o	
Ratio of Resistor Voltage to Source Voltage, $\frac{V_{R,rms}}{V_{S,rms}}$	
Square of Voltage Ratio = Power Ratio, $\left(\frac{V_{R,rms}}{V_{S,rms}}\right)^2$	

DATA SHEET, pg. 1/3	Name
Expt. #11 Resonance	Lab Partner

Table 11-1 Resistor, Capacitor and Inductor Values;

Predicted Resonant and Half-Power Frequencies. *Include units.*

Element	**Measured Value**	
3.0 kΩ resistor	R =	
33 mH Inductor	R_L =	
	L =	
0.1 μF Capacitor	C =	
Resonant frequency, calculated	ω_o =	f_o =
Frequency at $V_R = V_S / \sqrt{2}$	ω_1 =	f_1 =
	ω_2 =	f_2 =

DATA SHEET, pg. 2/3 **Expt. #11 Resonance**	Name
	Lab Partner

Table 11-2 Frequency and Voltage Measurements: RLC Circuit, **8.0 $V_{p\text{-}p}$ sine wave**.

Measured source signal: V_{pp} = ____________ V ; V_{rms} = ____________ V

f	***f***	$V_{R,rms}$	$V_{L,rms}$	$V_{C,rms}$
nominal	measured	measured	measured	measured
Units: **Hz**	**Hz**	**V**	**V**	**V**
100				
200				
300				
500				
1.0k				
2.0k				
3.0k				
5.0k				
10k				
20k				
30k				
50k*				
f_o =				

* A frequency of 50kHz may be pushing the limits of the oscilloscope, so readings at this level may not be valid.

Note: DMM measurements are V_{rms} values, not amplitudes V_p.

DATA SHEET, pg. 3/3	Name
Expt. #11 Resonance	Lab Partner

Table 11-3 Half-Power Measurements: RLC Circuit, **8.0 $V_{p\text{-}p}$ sine wave**

Nominal source signal amplitude V_S = 4.0 V.

Predicted amplitude of resistor voltage at half-power frequency (Step 4):

$V_{R,half\text{-}power} = 0.707 V_{R,max} = 0.707 V_S =$ ____________ V

	f	$V_{R,rms,half\text{-}power}$ **(*r.m.s.*)**	$V_{R,half\text{-}power}$ **(amplitude)**	***% Difference of*** V_R w.r.t. predicted
Units	Hz	V	V	%
f_1				
f_2				

Note: DMM measurements are V_{rms} values, not amplitudes V_p.

Convert measured r.m.s. values into amplitude values $\left(V_R = \sqrt{2}\, V_{R,rms}\right)$

Table 11-4 Measured Peak Voltages and Phases: RC Circuit, **8.0 $V_{p\text{-}p}$, 2000 Hz sine wave.**

Assume voltage source has zero phase: $\mathbf{V_S} = V_S \angle 0°$.

Measured peak-to-peak source signal: V_{pp} = _________ V, f = _________ Hz.

Predicted peak resistor voltage for given frequency: $V_{R,p}$ = _________ V.

Component	**Peak Voltage** V_p **(V)**	**Phase Angle** ϕ **(degrees)**	**Does the Component Lead or Lag the Source?**
Source		0.0°	
Resistor			
Inductor			
Capacitor			

This page intentionally left blank.