Name: Matt Forbes
Partner: Stuart
Section: Phys 233 - Thursday
TA: Ellis Roe

Lab 1: The Oscilloscope and its Uses

1 Purpose

The goal of lab 1 is to become familiar with the oscilloscope and oscillator; how to adjust the settings and read and interpret output from the screen. Most exercises in this lab revolved around experimenting with different settings on both the oscilloscope and the oscillator, learning how to calculate different parameters such as frequency and phase shift of the input wave. I would expect our results to be fairly accurate, with error only prevalent in our ability to fine tune settings and read measurements from the screen.

2 Procedure

In essence, each exercise was introducing a method of measurement for each property of the oscillator-generated wave, including the period/frequency, amplitude, phase shift, and frequency ratios.

3 Data

3.1 Exercise 1

In the first exercise, we are measured the period and frequency of the oscillator-generated wave using the equation:

$$T = (\#\text{ of horizontal cm}) * (\text{TIME/DIV setting})$$

After setting the oscillator and adjusting the oscilloscope, we simply measured the horizontal distance of a single period on the display. Obtaining the period was a simple matter of multiplying by the TIME/DIV setting.

Oscillator Frequency (Hz)	TIME/DIV	Period Length (cm)	Period (s)	Frequency (Hz)
20,000	10 μs	5 ± 0.1	0.00005	20,000
6,000	50 μs	3.4 ± 0.1	0.0017	5882
600	0.5 ms	3.4 ± 0.1	0.0017	588

3.2 Exercise 2

Here we measured the peak-to-peak amplitude of the wave, which is the length from the trough to the crest. Similar to exercise 1, we used a simple equation to determine the amplitude:

$$A = (\# \text{ of vertical cm}) * (\text{VOLTS/DIV setting})$$

We set the oscillator to each frequency, and measured the peak-to-peak vertical distance on the display. Multiplying by the VOLTS/DIV setting ¿gives us the amplitude.

Oscillator Frequency (Hz)	VOLTS/DIV (V)	Amplitude Length (cm)	Amplitude (V)
1,000	5	6 ± 0.2	30
500	5	6 ± 0.2	30
100,000	5	6 ± 0.2	30

3.3 Exercise 3

This exercise involved two waves, both generated from the same oscillator, but one is passed through a "phase shift network" which adjusts the phase shift of an input wave by a specified amount. Our goal here was to determine the actual shift generated by passing the wave through the network. We used three separate techniques to do this.

3.3.1 Dual-Trace Method

We first measure the length of a full period in cm, and divide by 360° which gives us the phase shift per cm. Next we measure the horizontal difference between the two waves on the screen and multiply by the previous ratio, giving us the phase shift.

Full Phase Length	6.6 ± 0.2 cm
Degrees per cm	$54.54°$
Phase Difference	1.2 ± 0.1 cm
Phase Shift	56.45

3.3.2 X-Y Method

The X-Y method is much less intuitive than the dual-trace. After switching the oscilloscope to X-Y mode, the display is a Lissajous figure depending on relative amplitudes and phase shifts of the two waves. Using the following equation, we can determine the phase shift:

$$\theta = sin^{-1}(\tfrac{A}{B})$$

Where A and B are certain dimensions of the Lissajous figure.

$A =$	5 ± 0.2 cm
$B =$	6 ± 0.2 cm
$\theta =$	$56.4°$

3.3.3 Sum Method

Finally, the sum method is used to determine the phase shift. This technique treats each wave as a vector. Using the sum of the two waves and a little trigonometry, we have the following equation which can be solved for our phase shift, θ:

$$Sum = A\sqrt{2 + 2\cos\theta}$$

Where Sum is equal to peak-to-peak amplitude of the sum of the original two waves, and A is equal to the peak-to-peak amplitude of a single original wave.

$$\begin{aligned} A &= 6 \\ Sum &= 9.75 \pm 0.4 \text{ cm} \\ 9.75 &= 6\sqrt{2 + 2\cos\theta} \\ \theta &= 71^\circ \end{aligned}$$

This measurement of θ is much different than the others, which is most likely due to the high error in Sum, which the screen was not large enough for us to read without scrolling.

3.4 Exercise 4

Having been introduced to the three methods of determining the phase shift, we now are asked to set the phase angle using the dual-trace method, and checking with the other two for consistency.

θ, Dual-Trace	θ, X-Y	θ, Sum
45°	49°	36°
90°	90°	88°
105°	68°	106°

In the first two cases, the X-Y method was very close while the Sum method was so-so. For some reason on the third case, 105°, we could not get the X-Y method to come close. We redid both the measurements and calculations multiple times to hopefully spot the reason for the error, but we couldn't. 105° is the ratio for angle per cm we used in our initial dual-trace calculations, which may be culprit. Either way, our uncertainties in measurements were about ± 0.2 cm in both methods. If we could only use one method, I'm not sure what I would pick, because neither the X-Y or Sum method were reliable. The dual-trace is probably the most straight forward, so I would go with that.

3.5 Exercise 4 (Challenge)

Our final exercise was to determine the frequency ratios of two different waves, each generated with its own oscillator, based on pictures of the Lissajous figure. Based on a helpful hint from Ellis, we were able to determine them all correctly. They appear in this order (vertically): $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{4}$, $\frac{3}{5}$, $\frac{4}{5}$, $\frac{5}{6}$.

4 Analysis

It seems that the uncertainty in measurements is a fairly large issue when using an oscilloscope. Our results from exercise 4 show this most clearly, we measured the same wave using three different methods, and got different results each time. Usually, the margin of error was around 0.1 to 0.2 cm which is quite large when you're talking about waves.

5 Conclusion

This lab was a hands-on way to learn our way around an oscilloscope, and brought to our attention the amount of uncertainty in its measuremnts. I am sure this tool will be utilized further in following labs.