Name:_______________________________________ Period ___ Date:________

# Lab: Introduction to Oscilloscopes (Halverson Physics and STEM)

Oscilloscopes are powerful, fun tools used by engineers, scientists, doctors, to make continuous graphs of voltages. The voltages can represent sounds, temperatures, computer logic levels (1's and 0's), someone's heartbeart, just about anything!

## Part 1

Please begin by watching this video and answering the questions:

halverscience.net > Electronics > Electronics Video > (1) Scope intro by Make:magazine.com: [https://www.youtube.com/watch?v=SxZWcku_Sw0](https://www.youtube.com/watch?v=SxZWcku_Sw0)

1. Does the guy look like an insane nerd? ____________. (Someday you will be so cool.)
2. What does the black alligator clip connect to? _______________
3. What does the probe hook connect to? ______________
4. The Y axis represents ________________. The X axis represent _________________.
5. The VOLTS/DIVISION rotary switch determines the amount of _____________ represented by each **vertical / horizontal** unit on the display's grid.
6. If the waveform is four units tall and the vertical gain is 0.5 V per division (grid line), then the amplitude of the wave is ______________ Volts peak-to-peak. ("Peak-to-peak" means from top to bottom. I think it comes from saying positive peak to negative peak.)
7. The TIME/DIVISION rotary switch adjusts the **vertical / horizontal** scale to a fraction of a second.
8. If the waveform repeats once every six horizontal units and the scale is set to 0.1 ms/division then the period of the waveform is __________________ (Don't forget the units!)
9. Match the times and voltages:

| | | |
|---|---|---|
| ms (milliseconds) | 0.000000001 s | $10^{-3}$ s |
| µs (microseconds) | 0.000001 s | $10^{-6}$ s |
| ns (nanoseconds) | 0.001 s | $10^{-9}$ s |
| mV (milliVolts) | 0.001 V | $10^{-3}$ V |
| µs (microseconds) | 0.00000001 V | $10^{-6}$ V |
| ns (nanoseconds) | 0.000001 V | $10^{-9}$ V |

10. The scope begins drawing the waveform at a voltage called the ____________ level. (Starts with t)
11. What type of scope is he using? **analog / digital** (It has that cool retro green glow...)

## Part 2

Get a digital oscilloscope, a scope probe and a power cord from Dr. H. (You could use Halverson's antique analog scope, but its only if you don't mind a steeper learning curve.)

- Plug in the power cord.
- Plug the probe into the CH 1 (Channel 1) BNC jack. (BNC is an industry-standard coaxial plug. The outer round part is ground. The inner hole has the voltage signal.)

- **Make sure the probe's plug is "locked" - turn it clockwise until it "clicks" or until it won't turn any further.**

The next several steps are described in the video here. (It has no sound, but its very easy to follow.)

halverscience.net > Electronics > Electronics Video > (2) Digital oscilloscope tutorial (no sound): https://www.youtube.com/watch?v=7nwIIPN9QEY

Put a signal into Channel 1 of the oscilloscope and adjust the scope to get a clear waveform (graph). To do this you can hook the probe to the calibration signal on the front of the scope. Its a small metal loop near the screen, labelled "PROBE COMP."

Hint: To get a clear waveform on a digital scope you can press "DEFAULT SETUP" and "AUTOSET" to get an OK display. On an analog scope, you might need to ask for help.

- Play with the scope's controls to see what they do.

The 1X / 10X switch on the probe causes the probe to optionally reduces the voltage by a factor of 10 (when in 10X position). It is confusing. On an analog scope you just have to keep it in mind.

- Digital scope only: Make sure that the 1X / 10X switch on the probe and the 1X / 10X in the scope setup agree. You can verify it by pressing CH 1 MENU.

To get credit for this lab, you will need to demonstrate the following things to Dr. H. (The video explains most of this.)

1. ____ Plug / unplug the probe's BNC connection.
2. ____ Make the 1X / 10X probe setting agree with the scope's setting (digital only) or show that you know how to account for it on an analog scope. (Its OK to ask for help on this one.)
3. ____ Change the vertical gain, aka the VOLTS/DIV.
4. ____ Explain how to measure the amplitude of a waveform based on (VOLTS/DIV) × (# of vertical divisions you see on the screen for one cycle).
5. ____ Change the vertical position of the trace. ("Trace" is an old word that means the "graph")
6. ____ Change the horizontal time scale, aka the SEC/DIV.
7. ____ Explain how to measure the period of a waveform based on (SEC/DIV) × (# of horizontal divisions you see on the screen).
8. ____ Change the horizontal position of the trace.
9. ____ Change the trigger level.

Note: The scope waits until the input voltage reaches the trigger level and then it begins drawing the graph. If the input voltage never reaches the trigger level then the scope gives up and draws the graph at random times.

10. ____ Demonstrate how to set the trigger level so that you have a stable waveform.

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## Part 3

Get a 9 VAC (Volts Alternating Current) power supply from Dr. H.

- Connect the probe (both the hook and the ground) to the two wires.
- Set the probe to 10X and make sure the scope is set up consistent with it. (Digital only. Press the CH1 MENU button to get to that function.)
- Get a stable waveform. It should look like a nice sinusoidal graph.

1. ____ Our electric power has a frequency of 60 Hz. What is the period? (Use f=1/T) ________________
2. ____ How many milliseconds is that? ___________________
3. ____ Verify the period of the signal, based on (SEC/DIV) × (# of horizontal divisions for one cycle).
4. ____ 9 Volts AC means that the amplitude (the maximum Voltage) should be 9 Volts, and the minimum should be -9 Volts. However, because of details of how AC works, it should actually be $9\times\sqrt{2} = 9\times1.414=$___________ Volts. Verify that the amplitude is at least that much. (When I tried it, I found that it is too big by about 2 Volts.) Do it based on (VOLTS/DIV) × (# of vertical divisions you see on the screen).
5. ____ Get a battery. (A 1.5 V AAA battery is OK.) Touch the probe's tip and ground clip to the two ends. Veryfy that the trace moves up (or down if you have the battery backwards) by the battery's voltage. (A fresh battery will have a bit more than 1.5 Volts.)
6. When you have done these things, show how you did it to Dr. H. for a stamp.

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## Part 4

- Return the battery and 9 VAC power supply to Dr. H.
- Get (1) the function generator and (2) the audio amplifier with clip leads.
- Connect the ground lead of the scope **and** the ground lead of the audio amplifier to the ground of the function generator. (Black leads) (The probe should be set to 10X)
- Connect the probe hook and the amplifier signal lead to one of the Sine/Triangle Ouptut.
- Turn on the function generator and amplifier. You should hear something from the amplifier and see a waveform on the scope.
- Play with the Amplitude Adjustment and Frequency Adjustment potentiometers and the Waveform Selector switch on the function generator.

1. Observe what happens and fill in this information:

| Changing this on the function generator... | changes the sound in this way and ... | changes the waveform in this way |
|---|---|---|
| Amplitude Adjustment | | |
| Frequency Adjustment | | |
| WaveForm Selector | | |

2. Get a second probe, set it to 10X and connect the BNC plug CH 2 of the scope. Connect the probe hook to the Square/TTL Output. Get a stable, readable waveform for both a triangle wave (CH 1) and the Square Wave (CH2). Sketch it here:

3. What can you say about the phase of the triangle wave vs the phase of the square wave? ("Phase" means the point in time that the waveform begins to go up.)

STAMP → (3.5/4)

4. Dr. H. will now "scramble" the scope and function generator settings. Your job is to get a stable waveform again by adjusting the scope. (Do not change the function generator settings.) and tell Dr. H. the new waveform period and amplitude.

New period = ___________________

New amplitdue = __________________

STAMP → (4/4)