The plan for Lab#1 is as follows:

1. Laboratory safety exam
2. Work with each equipment unit using below instructions
3. Using knowledge learned during 2., do lab experiments listed at the end of this instruction.

**GOALS:**

Introduce laboratory safety procedures to safeguard lives and properties. Provide a basic tutorial on the functions of laboratory equipment that will be utilized during the term. Upon conclusion of this work, the student will be familiar with safe lab working procedure and with the basic setup of the equipment used in this laboratory class experiments.

**SAFETY:**

Safety is the most important issue that impacts successful implementation of any lab experiments. Improper equipment usage not only damage property, it can potentially jeopardize your life as well lives of the fellow students. Carefully read the safety manual posted on class website. After reading the safety manual, you must take the safety exam and pass the exam to continue the class.

*Note: Your negligence in following the safety guidelines anytime during the semester will not be tolerated and you would be dropped from the class.*

**LAB SCHEDULE:**

The plan for Lab#1 is as follows:

1. Laboratory safety exam
2. Work with each equipment unit using below instructions
3. Using knowledge learned during 2., do lab experiments listed at the end of this instruction.
**EQUIPMENT USE:**

The following equipment is located at each station:

**AGILENT 34405A DIGITAL MULTI-METER**

Connections for different measurements as follows:
Measuring AC or DC Voltage

AC Voltage:
- Five Ranges: 100.000 mV, 1.00000 V, 10.0000 V, 100.000 V, 750.00 V
- Measurement Method: AC coupled true rms - measures the AC component with up to 400 VDC bias on any range.
- Crest Factor: Maximum 5:1 at full scale
- Input Impedance: 1 MΩ± 2% in parallel with <100pF on all ranges
- Input Protection: 750V rms on all ranges (HI terminal)

DC Voltage:
- Five Ranges: 100.000 mV, 1.00000 V, 10.0000 V, 100.000 V, 1000.00 V
- Measurement Method: Sigma Delta A-to-D converter
- Input Impedance: ~10 MΩ all ranges (typical)
- Input Protection: 1000V on all ranges (HI terminal)
Measuring Resistance

- Seven Ranges: 100.000Ω, 1.00000 kΩ, 10.0000 kΩ, 100.000 kΩ, 1.00000 MΩ, 10.0000 MΩ, 100.000 MΩ
- Measurement Method: two-wire ohms
- Open-circuit voltage limited to < 5 V
- Input protection 1000 V on all ranges (HI terminal)

Measuring AC (RMS) or DC Current up to 1.2A

- Three AC Current or DC Current Ranges: 10.0000 mA, 100.000 mA, 1.00000 A
- Shunt Resistance: 0.1Ω to 10 Ω for 10mA to 1A ranges
- Input Protection: Front Panel 1.25A, 500V FH fuse for I terminal
Measuring AC (RMS) or DC Current up to 12A

- 10 Amp AC Current or DC Current Range
- Shunt Resistance: 0.01 Ω for 10A range
- Internal 15A, 600V fuse for 12A terminal

Measuring Frequency

- Five Ranges: 100.000 mV, 1.00000 V, 10.0000 V, 100.000 V, 750.00 V. Range is based on the voltage level of the signal, not frequency.
- Measurement Method: Reciprocal counting technique.
- Signal level: 10% of range to full scale input on all ranges
- Gate Time: 0.1 second or 1 period of the input signal, whichever is longer.
- Input Protection: 750V rms on all ranges (HI terminal)
Testing Continuity

- Measurement Method: 0.83 mA ± 0.2% constant current source, < 5 V open circuit voltage.
- Response Time: 70 samples/second with audible tone
- Continuity Threshold: 10 Ω fixed
- Input Protection: 1000 V (HI terminal)

Checking Diodes

- Measurement Method: Uses 0.83 mA ± 0.2% constant current source, < 5 V open circuit voltage.
- Response Time: 70 samples/second with audible tone
- Input Protection: 1000 V (HI terminal)
Measuring Capacitance

- Eight ranges: 1nF, 10nF, 100nF, 1μF, 10μF, 100μF, 1000μF, 10,000μF and autorange
- Measurement Method: Computed from constant current source charge time. Typical 0.2V - 1.4V AC signal level
- Input Protection: 1000 V (HI terminal)

![Typical Display of Capacitance Measurement](image)

Measuring Temperature

- -80.0°C to 150.0 °C, -110.0°F to 300.0 °F
- Auto-ranging measurement, no manual range selection
- Measurement Method: 2-wire Ohms measurement of 5 kΩ thermistor sensor (E2308A) with computed conversion
- Input Protection: 1000 V (HI terminal)

![Typical Display of Temperature Measurement](image)
Selecting a Range

You can let the multimeter automatically select the range using *autoranging*, or you can select a fixed range using *manual ranging*. Autoranging is convenient because the multimeter automatically selects the appropriate range for sensing and displaying each measurement. However, manual ranging results in better performance, since the multimeter does not have to determine which range to use for each measurement.

- Selects a lower range and disables autoranging.
- Selects a higher range and disables autoranging.
- Selects autoranging and disables manual ranging.

- The **ManRng** annunciator is on when manual range is enabled.
- Autoranging is selected at power-on and after a remote reset.
- Manual ranging – If the input signal is greater than can be measured on the selected range, the multimeter provides these overload indications: **OL** from the front panel or “±9.9E+37” from the remote interface.
- For frequency measurements, ranging applies to the signal’s input voltage, not its frequency.
- The range is fixed for continuity (1 kΩ range) and diode (1 VDC range).
- The multimeter remembers the selected ranging method (auto or manual) and the selected manual range for each measurement function.
- Autorange thresholds – The multimeter shifts ranges as follows:  
  - Down range at <10% of current range  
  - Up range at >120% of current range
Setting the Resolution

You can select either 4½ or 5½-digit resolution for the DCV, DCI, resistance, ACV, ACI and frequency measurement functions.
- 5½-digit readings have the best accuracy and noise rejection.
- 4½-digit readings provide for faster readings.
- The continuity and diode test functions have a fixed, 4½-digit display.
- Capacitance and temperature have a fixed 3½-digit display.

1. **Gather Necessary Materials:**
   a) Grab (1) red and (1) black test lead from the supply closet.
   b) Choose any resistor from the parts bin and record the value that is labeled.

2. **Configure Multimeter**
   a) Refer to the image provided below in order to properly connect the test leads.
   b) Turn on the multimeter by pressing the power button located towards the bottom left of the faceplate.
   c) Press the button to enable resistor reading mode.
   d) Press to enable auto ranging mode.

3. **Measure the Resistance (auto range)**
   a) Use the red test lead to make contact with one metal end of the resistor while simultaneously using the black test lead to make contact with the other metal end. Be sure that your fingers are not touching the resistor as your internal resistance can skew the results of the procedure.
   b) Examine the resistance reading provided from the multimeter and confirm it matches the value you documented from step (1).
4. Measure the Resistance (manual range)
   a) Press the or button to escape auto ranging mode then again to cycle through the manual range options. Once you’ve found the desired resistance range, repeat steps (g) and (h) and confirm that your results agree.

![Test Lead Configuration for Resistance Measurement](image)

**AGILENT 3648A LABORATORY DC POWER SUPPLY**
1: Output1 selection Key
2: Output2 selection Key
3: Low voltage range selection Key
4: High voltage range selection Key
5: Overvoltage protection Key
6: Display limit Key
7: Resolution selection Keys
8: Voltage / Current adjust selection Key
9: Knob
10: Output On / Off Key
11: I/O Configuration Menu / Secure Key
12: View Menu / Calibrate Key
13: State Storage Menu / Local Key
14: Stored state Recall/Reset Menu
15: Tracking enabling/disabling Key
Procedure: Constant Voltage Operation

1. Connect a load to the output terminals:
   With power-off, connect a red banana cable to the (+) terminal and a black banana cable to the (-) terminal.

2. Turn on the power supply:
   Power the power supply by pressing the power button located towards the bottom left of the faceplate. By default the output will be disabled, CH1 will be selected, and the low voltage range will be selected. For future reference, voltages greater than 8V can be achieved by pressing the button.

3. Set the display to the limit mode:
   Press the “Display Limit” button to enter limit mode.

   **Note:** It is extremely important that the current is limited before conducting any type of procedures are conducting with the power supply. By regulating the current we are able to add an extra layer of protection to our circuits. When in doubt consult the datasheet of the IC’s (integrated circuit) you plan to use in order to determine their current limitations.

4. Adjust the knob for the desired current limit:
   Check that the Limit annunciator still flashes. Press the button to toggle between the voltage and current selections. The flashing digit can be changed using the resolution selection keys and the flashing digit can be adjusted by turning the knob. Adjust the knob so that the current limit reads 50mA (0.05A). Press the once more to escape limit mode.

5. Adjust the knob for the desired output voltage:
   Check that the Limit annunciator is no longer active. Press the button to toggle between the voltage and current selections. Set the knob for voltage control. Change the flashing digit using the resolution selection keys and adjust the knob so that the voltage reads 5V.

6. Enable the output:
   Press the button. The OFF annunciator turns off and the CV annunciator turns on. Notice that the display is in the meter mode.

7. Verify that the power supply is in the constant voltage mode:
   If you operate the power supply in the constant voltage (CV) mode, verify that the CV annunciator is lit. If the CC annunciator is lit, choose a higher current limit.
Procedure: Constant Current Operation

1. Connect a load to the output terminals:
   With power-off, connect a red banana cable to the (+) terminal and a black banana cable to the (-) terminal.

2. Turn on the power supply:
   Power the power supply by pressing the power button located towards the bottom left of the faceplate. By default the output will be disabled, CH1 will be selected, and the low voltage range will be selected. For future reference, voltages greater than 8V can be achieved by pressing the button.

3. Set the display to the limit mode:
   Press the “Display Limit” button to enter limit mode.

   Note: It is extremely important that the current is limited before conducting any type of procedures are conducting with the power supply. By regulating the current we are able to add an extra layer of protection to our circuits. When in doubt consult the datasheet of the IC’s (integrated circuit) you plan to use in order to determine their current limitations.

4. Adjust the knob for the desired voltage limit:
   Check that the Limit annunciator still flashes. Press the button to toggle between the voltage and current selections. The flashing digit can be changed using the resolution selection keys and the flashing digit can be adjusted by turning the knob. Adjust the knob so that the voltage limit reads 5V. Press the once more to escape limit mode.

5. Adjust the knob for the desired output current:
   Check that the Limit annunciator still flashes. Press the button to toggle between the voltage and current selections.. Change the flashing digit using the resolution selection keys and adjust the knob to the desired output current of 100mA (0.1A).

6. Enable the output:
   Press the button. The OFF annunciator turns off and the CC annunciator turns on. Notice that the display is in the meter mode.

7. Verify that the power supply is in the constant current mode:
   If you operate the power supply in the constant current (CC) mode, verify that the CC annunciator is lit. If the CV annunciator is lit, choose a higher voltage limit.
**Procedure: Tracking Operation**

This power supply provides tracking outputs. In the track mode, two voltages of the output #1 and the output #2 supplies track each other within the voltage programming accuracy. The track mode is always off state when power has been off or after a remote interface reset.

1. **Set either the output #1 or the output #2 supply to the desired voltage.**

2. **Enable the track mode:**
   Hold down key until the **Track** annunciator turns on. For example, when the track mode is first enabled with the output #1 selected, the output #2 supply will be set to the same voltage level as the output1 supply. Once enabled, any change of the voltage level in either the output1 or the output2 supply will be reflected in other supply. The current limit is independently set for each of the output1 or the output2 supply and is not affected by the track mode.

3. **Exit the track mode:**
   The **Track** annunciator turns off.
1: Power Switch  
2: Voltage Display (CH1)  
3: Amperage Display (CH1)  
4: Voltage Display (CH2)  
5: Amperage Display (CH2)  
6: Voltage Control Knob (CH1)  
7: Current Control Knob (CH1)  
8: Voltage Control Knob (CH2)  
9: Current Control Knob (CH2)  
10: N/A  
11: N/A  
12: N/A  
13: N/A  
14: Overload Indicator  
15: Constant Voltage/Current Indicator (CH1)  
16: Constant Voltage/Current Indicator (CH2)  
17: N/A  
18: Output Indicator  
19: (+) Output Terminal (5V 3A Fixed)  
20: (-) Output Terminal (5V 3A Fixed)  
21: (+) Output Terminal (CH1)  
22: (-) Output Terminal (CH1)  
23: Ground Terminal  
24: (+) Output Terminal (CH2)  
25: (-) Output Terminal (CH2)  
26: N/A  
27: N/A  
28: Output Switch  
29: Tracking Mode Switch (CH2)  
30: Tracking Mode Switch (CH1)

In the TBE-B350 lab the GW Instek GPS-3303 DC power supplies are paired with a HP 34688 multimeter. The instruction below accounts for these special cases.
Procedure: Constant Current Operation

1. Setting up the Multimeter
   a) Grab (2) red and (2) black banana leads cable from the supply closet.
   b) We connect the two lead cables as indicated in the picture below. The red cable needs to be placed in the terminal labeled ‘A’ (amperage) since we will be reading a current value.
   c) Turn on the multimeter by pressing the power button located towards the left side of the face plate.
   d) Press the button in order to measure DC currents.

2. Setting up the Power Supply
   a) Ensure all of the knobs are turned all the way down (towards the left).
   b) Connect a red banana lead cable to the (+) output terminal of CH2 and a black banana lead cable to the (–) output terminal of CH2.
   c) Connect the red banana lead cable to the other red banana lead cable from the multimeter. Afterwards, connect the black banana lead cable to the other black banana lead cable from the multimeter.
   d) Slowly turn the CH2 current knob until the display reads 30mA (0.03A).
   e) Press in the output switch located on the left of the faceplate.
   f) Confirm the reading on the multimeter is around 30mA.

Procedure: Constant Voltage Operation

1. Setting up the Multimeter
   a) Follow steps (a) through (c) in the “Constant Current Output” section above (Setting up the Multimeter).
   b) Press the button in order to measure DC voltage.

2. Setting Up the Power Supply
   a) Follow steps (a) through (d) in the “Constant Current Output” section above (Setting Up the Power Supply).
   b) Slowly turn the CH2 current knob until the display reads 5V.
   c) Press in the output switch located on the left of the faceplate.
   d) Confirm the reading on the multimeter is around 5V.
**Instek Function Generator GFG-3015**

- **Power Switch**: Used to power the device on or off.
- **LCD Display**: Displays data relevant to the current operation.
- **Function Keys**: Allows the user to choose various options, depending on the operation mode.
- **Scroll Wheel**: Can be used in conjunction with the arrow keys to alter the value of a given parameter.
- **Arrow Keys**: Mainly used to cycle through digits when adjusting the value of a parameter.
- **Number Pad**: Used to key in values for parameters.
- **Operation Keys**: Used to select operation parameters such as the waveform, frequency, amplitude, and offset.
- **Output Key**: Once activated the function generator will produce an output signal from channel 1 or channel 2.
- **Channel Select Key**: Allows the user to toggle between channel 1 or channel 2.
- **Output Terminals**: Channel outputs with a built-in resistance of 50 ohms.
Procedure: Function Generator Operation (Sine Wave)

1. Selecting the Waveform
   a) Turn on the function generator by pressing the power button.
   b) Once the LCD display no longer shows the default start-up screen, press the button.
   c) Immediately to the left of the function keys you’ll notice that there are various waveforms that we can choose from. In this example we’ll make use of the sine wave. Press the button labeled in order to select the sine waveform. Afterwards, the LCD display will show an image of a sine wave on the bottom while the top portion will display a few parameters we will configure in the next steps.

2. Selecting the Frequency
   a) Press the button. Notice how the field labeled “FREQ” is now highlighted.
   b) We want to set the frequency at 10 kHz. To do so, use the keypad to enter the number ‘10’ followed by the button (for kHz). You can also use the keys with the scroll wheel to select the frequency value.

3. Selecting the Amplitude
   a) Press the button. Notice how the field labeled “AMPL” is now highlighted.
   b) Use the keypad to enter the number ‘1’ followed by the button (for peak-to-peak voltage). You can also use the keys with the scroll wheel to select the amplitude value.

4. Selecting the Offset
   a) Press the button. Notice how the field labeled “Offset” is now highlighted.
   b) Use the keypad to enter the number ‘0.5’ followed by the button (for DC Voltage). You can also use the keys with the scroll wheel to select the offset value.

5. Examining the Results
   a) From the supply closet, grab (1) BNC to IC test clip cable and also (1) oscilloscope probe.
   b) Connect the oscilloscope probe to the terminal labeled CH1 on the oscilloscope. Afterwards, press the power button located on the top of the oscilloscope to turn it on.
   c) Connect the coax end of the BNC to terminal labeled CH1 on the function generator.
   d) Ensure that the above parameters have been correctly set and then press the button.
   e) Connect the black clip of the BNC to IC cable to the ground clip on the oscilloscope, and the red clip to the actual oscilloscope probe.
   f) On the oscilloscope press the button labeled “DEFAULT SETUP” then the button labeled “AUTO SET” and compare results with the images below.
Note: The above oscilloscope instructions are provided solely for a quick visual representation of the output from the function generator. In order to obtain more accurate results, usually the user will configure the oscilloscope manually and not use the “AUTO SET” option. Also, VPP refers to the peak-to-peak voltage. However, the AFG-2225 defines VPP as the peak voltage. Notice how the peak-to-peak voltage is measured at 2V (at 500mV volts/div).

Tektronix TDS 2014 Four Channel Digital Storage Oscilloscope
1- Icon display shows acquisition mode.
   - Sample mode
   - Peak detect mode
   - Average mode

2- Trigger status indicates the following:
   - Armed. The oscilloscope is acquiring pretrigger data. All other triggers are ignored.
   - Ready. All pretrigger data has been acquired and the oscilloscope is ready to accept a trigger.
   - Trig’d. The oscilloscope has seen a trigger and is acquiring the posttrigger data.
   - Stop. The oscilloscope has stopped acquiring waveform data.
   - Acq. Complete. The oscilloscope has completed a Single Sequence acquisition.
   - Auto. The oscilloscope is in auto mode and is acquiring waveforms in the absence of triggers.
   - Scan. The oscilloscope is acquiring and displaying waveform data continuously in scan mode.

3- Marker shows horizontal trigger position. Turn the HORIZONTAL POSITION knob to adjust the position of the marker.
4- Readout shows the time at the center graticule. The trigger time is zero.
5- Marker shows Edge or Pulse Width trigger level.
6- On-screen markers show the ground reference points of the displayed waveforms. If there is no marker, the channel is not displayed.
7- An arrow icon indicates that the waveform is inverted.
8- Readouts show the vertical scale factors of the channels.
9- A BW icon indicates that the channel is bandwidth limited.
10- Readout shows main time base setting.
11- Readout shows window time base setting if it is in use.
12- Readout shows trigger source used for triggering.
13- Icon shows selected trigger type as follows:
   - Edge trigger for the rising edge.
   - Edge trigger for the falling edge.
   - Video trigger for line sync.
   - Video trigger for field sync.
   - Pulse Width trigger, positive polarity.
   - Pulse Width trigger, negative polarity.
14- Readout shows Edge or Pulse Width trigger level.
15- Display area shows helpful messages; some messages display for only three seconds.
   If you recall a saved waveform, readout shows information about the reference waveform, such as RefA 1.00V 500μs.
16- Readout shows trigger frequency.
Functional Check

Perform this functional check to verify that your oscilloscope is operating correctly.

1. Power on the oscilloscope.
   Push the DEFAULT SETUP button.
   The default Probe option attenuation setting is 10X.

2. Set the switch to 10X on the P2220 probe and connect the probe to channel 1 on the oscilloscope. To do this, align the slot in the probe connector with the key on the CH 1 BNC; push to connect, and twist to the right to lock the probe in place.
   Connect the probe tip and reference lead to the PROBE COMP terminals.

3. Push the AUTOSET button. Within a few seconds, you should see a square wave in the display of about 5V peak-to-peak at 1 kHz.
   Push the CH1 MENU button on the front panel twice to remove channel 1, push the CH 2 MENU button to display channel 2, and repeat steps 2 and 3. For 4-channel models, repeat for CH 3 and CH 4.
Probing Safety

Check and observe probe ratings before using probes.

A guard around the P2220 probe body provides a finger barrier for protection from electric shock.

![Finger guard]

⚠️ WARNING. To avoid electric shock when using the probe, keep fingers behind the guard on the probe body.

To avoid electric shock while using the probe, do not touch metallic portions of the probe head while it is connected to a voltage source.

Connect the probe to the oscilloscope, and connect the ground terminal to ground before you take any measurements.

Voltage Probe Check Wizard

You can use the Probe Check Wizard to verify that a voltage probe is operating properly. The wizard does not support current probes.

The wizard helps you adjust the compensation for voltage probes (usually with a screw on the probe body or probe connector) and set the factor for the Attenuation option for each channel, such as in the CH 1 MENU ➤ Probe ➤ Voltage ➤ Attenuation option.
You should use the Probe Check Wizard each time you connect a voltage probe to an input channel.

To use the Probe Check Wizard, push the **PROBE CHECK** button. If the voltage probe is connected properly, compensated properly, and the Attenuation option in the oscilloscope VERTICAL menu is set to match the probe, the oscilloscope displays a PASSED message at the bottom of the screen. Otherwise, the oscilloscope displays directions on the screen to guide you in correcting these problems.

**NOTE.** The Probe Check Wizard is useful for 1X, 10X, 20X, 50X, and 100X probes. It is not useful for 500X or 1000X probes, or for probes connected to the **EXT TRIG BNC.**

**NOTE.** When the process is complete, the Probe Check Wizard restores the oscilloscope settings (other than the Probe option) to what they were before you pushed the **PROBE CHECK** button.

To compensate a probe that you plan to use with the **EXT TRIG** input, follow these steps:

1. Connect the probe to any input channel BNC, such as to CH 1.
2. Push the **PROBE CHECK** button and follow the directions on the screen.
3. After you verify that the probe functions and is compensated properly, connect the probe to the **EXT TRIG** BNC.
Manual Probe Compensation

As an alternative method to the Probe Check Wizard, you can manually perform this adjustment to match your probe to the input channel.

1. Push the CH 1 MENU ► Probe ► Voltage► Attenuation option and select 10X. Set the switch to 10X on the P2220 probe and connect the probe to channel 1 on the oscilloscope. If you use the probe hook-tip, ensure a proper connection by firmly inserting the tip onto the probe.

2. Attach the probe tip to the PROBE COMP -5V@1kHz terminal and the reference lead to the PROBE COMP chassis terminal. Display the channel, and then push the AUTOSET button.

3. Check the shape of the displayed waveform.

4. If necessary, adjust your probe. The P2220 probe is shown.

Probes are available with various attenuation factors which affect the vertical scale of the signal. The Probe Check Wizard verifies that the attenuation factor in the oscilloscope matches the probe.

As an alternative method to Probe Check, you can manually select the factor that matches the attenuation of your probe. For example, to match a probe set to 10X connected to CH 1, push the CH 1 MENU ► Probe ► Voltage ► Attenuation option, and select 10X.
If you change the Attenuation switch on the P2220 probe, you also need to change the oscilloscope Attenuation option to match. Switch settings are 1X and 10X.

![Attenuation switch]

**NOTE.** When the Attenuation switch is set to 1X, the P2220 probe limits the bandwidth of the oscilloscope to 6 MHz. To use the full bandwidth of the oscilloscope, be sure to set the switch to 10X.

### Current Probe Scaling

Current probes provide a voltage signal proportional to the current. You need to set the oscilloscope to match the scale of your current probe. The default scale is 10 A/V.

For example, to set the scale for a current probe connected to CH 1, push the CH 1 MENU ➤ Probe ➤ Current ➤ Scale option, and select an appropriate value.

### Vertical Controls

![Vertical controls]

All models, 4-channel shown

- **POSITION (CH 1, CH 2, CH 3 & CH 4).** Positions a waveform vertically.

- **CH 1, CH 2, CH 3 & CH 4 MENU.** Displays the Vertical menu selections and toggles the display of the channel waveform on and off.

- **VOLTS/DIV (CH 1, CH 2, CH 3 & CH 4).** Selects vertical scale factors.

- **MATH MENU.** Displays waveform math operations menu and toggles the display of the math waveform on and off.
Horizontal Controls

**POSITION.** Adjusts the horizontal position of all channel and math waveforms. The resolution of this control varies with the time base setting. (See page 87, *Window Zone.)*

```
NOTE. To make a large adjustment to the horizontal position, turn the SEC/DIV knob to a larger value, change the horizontal position, and then turn the SEC/DIV knob back to the previous value.
```

**HORIZ MENU.** Displays the Horizontal Menu.

**SET TO ZERO.** Sets the horizontal position to zero.

**SEC/DIV.** Selects the horizontal time/div (scale factor) for the main or the window time base. When Window Zone is enabled, it changes the width of the window zone by changing the window time base. (See page 87, *Window Zone.*)
Trigger Controls

2-channel model

**LEVEL.** When you use an Edge or Pulse trigger, the LEVEL knob sets the amplitude level that the signal must cross to acquire a waveform.

**TRIG MENU.** Displays the Trigger Menu.

**SET TO 50%.** The trigger level is set to the vertical midpoint between the peaks of the trigger signal.

**FORCE TRIG.** Completes an acquisition regardless of an adequate trigger signal. This button has no effect if the acquisition is already stopped.

**TRIG VIEW.** Displays the trigger waveform in place of the channel waveform while you hold down the TRIG VIEW button. Use this to see how the trigger settings affect the trigger signal, such as trigger coupling.
Taking Simple Measurements

You need to see a signal in a circuit, but you do not know the amplitude or frequency of the signal. You want to quickly display the signal and measure the frequency, period, and peak-to-peak amplitude.

Using Autoset

To quickly display a signal, follow these steps:

1. Push the CH 1 MENU button.
2. Push Probe ► Voltage ► Attenuation ► 10X.
3. Set the switch to 10X on the P2220 probe.
4. Connect the channel 1 probe tip to the signal. Connect the reference lead to the circuit reference point.
5. Push the AUTOSET button.

The oscilloscope sets the vertical, horizontal, and trigger controls automatically. If you want to optimize the display of the waveform, you can manually adjust these controls.

NOTE. The oscilloscope displays relevant automatic measurements in the waveform area of the screen based on the signal type that is detected.

For oscilloscope-specific descriptions, refer to the Reference chapter. (See page 79, Autoset.)

Taking Automatic Measurements

The oscilloscope can take automatic measurements of most displayed signals.

NOTE. If a question mark (?) appears in the Value readout, the signal is outside the measurement range. Adjust the VOLTS/DIV knob of the appropriate channel to decrease the sensitivity or change the SEC/DIV setting.
To measure signal frequency, period, and peak-to-peak amplitude, rise time, and positive width, follow these steps:

1. Push the MEASURE button to see the Measure Menu.
2. Push the top option button; the Measure 1 Menu appears.
3. Push Type ▸ Freq.
   The Value readout displays the measurement and updates.
4. Push the Back option button.
5. Push the second option button from the top; the Measure 2 Menu appears.
6. Push Type ▸ Period.
   The Value readout displays the measurement and updates.
7. Push the Back option button.
8. Push the middle option button; the Measure 3 Menu appears.
9. Push Type ▸ Pk-Pk.
   The Value readout displays the measurement and updates.
10. Push the Back option button.
11. Push the second option button from the bottom; the Measure 4 Menu appears.
   The Value readout displays the measurement and updates.
13. Push the Back option button.
14. Push the bottom option button; the Measure 5 Menu appears.
15. Push Type ▸ Pos Width.
   The Value readout displays the measurement and updates.
16. Push the Back option button.
Measuring Two Signals

If you are testing a piece of equipment and need to measure the gain of the audio amplifier, you will need an audio generator that can inject a test signal at the amplifier input. Connect two oscilloscope channels to the amplifier input and output as shown next. Measure both signal levels and use the measurements to calculate the gain.

To activate and display the signals connected to channel 1 and to channel 2, and select measurements for the two channels, follow these steps:

1. Push the AUTOSET button.
2. Push the MEASURE button to see the Measure Menu.
3. Push the top option button; the Measure 1 Menu appears.
5. Push Type ▶ Pk-Pk.
6. Push the Back option button.
7. Push the second option button from the top; the Measure 2 Menu appears.
9. Push Type ► Pk-Pk.
10. Push the Back option button.
   Read the displayed peak-to-peak amplitudes for both channels.
11. To calculate the amplifier voltage gain, use these equations:

\[
\text{Voltage Gain} = \frac{\text{output amplitude}}{\text{input amplitude}}
\]
\[
\text{Voltage Gain (dB)} = 20 \times \log_{10}(\text{Voltage Gain})
\]

**Connecting oscilloscope and function generator**
The oscilloscope probe is the only thing you can connect to the oscilloscope:

Oscilloscope probe

The function generation cable can be only connected to function generator:

Function generator cable

Remember that you CANNOT connect function generator cable to oscilloscope.
LAB DELIVERIES:

PRELAB:

Equipment Usage:
Review video lectures on equipment usage posted on the class website.

Lab Experiments:
For experiments 1-3, record all the steps as a write-down list, and take a picture of the result.

Experiment 1: DC Power Supply Set Up with Multimeter
Goal:
- connecting DC power supply to the multimeter
- changing the power supply output values and verifying them on the multimeter.

a) Turn on power supply with Power and Output Switch buttons. In addition, power the multimeter and set for volts and the “200” range or the nearest appropriate one.
b) Turn both the Current and Voltage knobs of Channel 1 fully counter clockwise of CH 1.
c) Connect red banana lead from “V − Ω” of multimeter to “+” of power supply and black banana lead from “com” of multimeter to “−” of power supply.
d) Slowly turn current knob until C-C LED turns from red to green. Next turn the voltage knob until the display indicates 10.0V. Verify this reading on the multimeter.
e) Experiment with other power supply voltage values.

Experiment 2: DC Power Supply Set Up with Oscilloscope
Goal:
- connecting DC power supply to the oscilloscope
- measuring DC power supply output voltage with the oscilloscope

a) Initially set up the oscilloscope
   a. Press Auto button
   b. The following can be observed on the oscilloscope display and can be changed with the adjacent buttons.
      c. Select the “CH1” button and set to the following in the corresponding column:
         Coupling:     Ground
         BW Limit:    Off
         Volts/Div:   Coarse
         Probe:       1x
         Invert:      Off
   d. Connect the coax measurement cable from channel 1 of the oscilloscope to the output of the power supply. Adjust the trace position knob on the oscilloscope to the middle of the display. This sets our reference position for measurements.
b) Adjust the power supply voltage to 5.0V and then to 10.0V. The trace on the oscilloscope should remain at the same reference position.
c) Experiment with other power supply voltages and change the Volts/Div knob accordingly in order to indicate the value on the oscilloscope.
Experiment 3: Signal Generator Setup with Oscilloscope

Goal:
- Setting up the function generator
- Connecting the function generator to the oscilloscope
- Verifying the function generator setting on the oscilloscope display

a) Initially set up the signal generator (be sure the CH1 Coupling is DC and do not change the other oscilloscope settings)
   a. Set the frequency generator to output a sinusoid with a frequency of 1kHz with an amplitude of 0.50V and an offset of 0.00V
   b. Connect a coax measurement cable from the output of the signal generator to the coax measurement cable of the oscilloscope.

b) Set the Time/Div knob on the oscilloscope to 500 μs. This will allow us to view one period in two horizontal divisions. In addition set the Volts/Div knob to 500mV, thus providing two vertical division for the sinusoid to be displayed. The signal should be symmetrical about the reference position of the oscilloscope.

c) Change the offset of the signal generator to 0.50V. The amplitude and frequency of the measured signal should not change though it should shift one vertical division as the DC component of the signal is now 500mV.

d) Experiment with other signal generator settings and adjust the oscilloscope as necessary.

Experiment 4: Demonstrate the following to TA:

1. Power Supply:
   - Show: how to set up the supply for positive and negative valued voltages.
   - Show: proper set-up of the ground.

2. Function Generator:
   - Show: how to set a given frequency and amplitude.
   - Show: how to provide a DC offset.
   - Answer: what is the difference between Main and Sync outputs.

3. Multimeter:
   - Show: how to measure voltage and resistance.
   - Answer: how to properly use the range settings.
   - Answer: When is the multi-meter the appropriate instrument and when it is not

4. Oscilloscope
   - Show: how to adjust probe.
   - Show: how to properly display a wave shape(s).
   - Show: how to measure voltage and frequency (with cursors and division counting)