INTRODUCTION TO THE GENERAL ELECTRONICS LABORATORY AND ELECTRONIC INSTRUMENTATION

1.- THE GENERAL ELECTRONICS LABORATORY

INSTRUMENTATION:
- Oscilloscope (Analog vs. Digital)
- Power Supply: DC Voltage
- Waveform Generator: AC Voltage
- Handheld Digital Multimeter (DMM)
- Bench DMM

ACCESSORIES:
- Components: Resistors, Capacitors, etc.
- Cables, connectors, wires
- Breadboards (prototype boards)

OPERATIONS:
- Switch on side of workbench
- Main switch for lab

2.- SAFETY

- Electronic circuits: Low-voltage. Relatively safe against electrocution
- Equipment energized at 110 Volts. Careful

Hazardous variable: Current

<table>
<thead>
<tr>
<th>Current level (in milliamperes)</th>
<th>Probable effect on human body</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mA</td>
<td>Perception level. Slight tingling sensation. Still dangerous under certain conditions.</td>
</tr>
<tr>
<td>5 mA</td>
<td>Slight shock felt; not painful but disturbing. Average individual can let go. However, strong involuntary reactions to shocks in this range may lead to injuries.</td>
</tr>
</tbody>
</table>
### Current Intervals and Effects

<table>
<thead>
<tr>
<th>Current Interval</th>
<th>Effect Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-30 mA</td>
<td>Painful shock, muscular control is lost. This is called the freezing current or &quot;let-go&quot; range.</td>
</tr>
<tr>
<td>50-150 mA</td>
<td>Extreme pain, respiratory arrest, severe muscular contractions. Individual cannot let go. Death is possible.</td>
</tr>
<tr>
<td>1000-4300 mA</td>
<td>Ventricular fibrillation (the rhythmic pumping action of the heart ceases.) Muscular contraction and nerve damage occur. Death is most likely.</td>
</tr>
<tr>
<td>10,000 mA</td>
<td>Cardiac arrest, severe burns and probable death.</td>
</tr>
</tbody>
</table>

- Wet conditions are common during low-voltage electrocutions. Under dry conditions, human skin is very resistant. Wet skin dramatically drops the body's resistance.

  Dry Conditions: Current = Volts/Ohms = 120/100,000 = 1mA a barely perceptible level of current

  Wet conditions: Current = Volts/Ohms = 120/1,000 = 120mA sufficient current to cause ventricular fibrillation

- If the extensor muscles are excited by the shock, the person may be thrown away from the circuit. Often, this can result in a fall from elevation that kills a victim even when electrocution does not.

- When muscular contraction caused by stimulation does not allow the victim to free himself from the circuit, even relatively low voltages can be extremely dangerous, because the degree of injury increases with the length of time the body is in the circuit. LOW VOLTAGE DOES NOT IMPLY LOW HAZARD!
  
  100mA for 3 seconds = 900mA for .03 seconds in causing fibrillation

- Note that a difference of less than 100 milliamperes exists between a current that is barely perceptible and one that can kill.
3.- RESISTORS

Color codes used to specify resistor values. Normally 2 bands and multiplier. 3rd band only used in precision resistors.

<table>
<thead>
<tr>
<th>COLOR</th>
<th>1st BAND</th>
<th>2nd BAND</th>
<th>3rd BAND</th>
<th>MULTIPLIER</th>
<th>TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1Ω</td>
<td>± 1%</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10Ω</td>
<td>± 1%      (F)</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>100Ω</td>
<td>± 2%      (G)</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1KΩ</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>10KΩ</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>100KΩ</td>
<td>±0.5%     (D)</td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>1MΩ</td>
<td>±0.25%    (C)</td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>10MΩ</td>
<td>±0.10%    (B)</td>
</tr>
<tr>
<td>Grey</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td></td>
<td>±0.05%</td>
</tr>
<tr>
<td>White</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>± 5%      (J)</td>
</tr>
<tr>
<td>Silver</td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
<td>± 10%     (K)</td>
</tr>
</tbody>
</table>

Manufacturers only produce resistors of specific values: Standard values of resistors
Resistors are measured using the DMM configured to measure Resistance

PROCEDURE:

1. Ensure there is no power in circuit or resistor.

2. Connect black lead to terminal COM

3. Connect red lead to terminal with symbol Ω

4. Move selector to measure Ω

5. LCD shows value of resistance.

6. If no value is displayed, select higher range.

Activity 1. Measurement of resistors

Select 5 resistors of different nominal values.

Create a data table in your laboratory notebook that has the following column headings: “resistor color code” (leave sufficient horizontal space to record four colors for each resistor), “nominal value”, “tolerance”, “measured value” and “% error”.

Measure and record data for each of the five resistors. Use the following procedure for each resistor:

   a. Record the complete color code (e.g., “rd br bk gd”).
   b. Record the nominal value and tolerance by interpreting the color code.
   c. Measure the resistance by attaching the clip of the black, banana-to-clip cable to one lead of the resistor and the clip of the red, banana-to-clip cable to the other lead.
   d. Record the measured resistance; be certain to include units.
   e. Calculate the % error using the following formula:

      \[ % \text{error} = \frac{\text{measured value} - \text{nominal value}}{\text{nominal value}} \times 100\% \]

Turn off the DMM, disconnect the cables and return the resistors to the appropriate boxes.
Activity 2. The prototyping solderless breadboard

Use horizontal strips to connect input voltages, grounds, etc. Ensure that in your connections you don’t short circuit the elements.

2.1 Build the following circuit in your breadboard:

- Calculate the theoretical resistance as seen from the free terminals.
- Measure the resistance with your DMM. Calculate the % of error. If the % error is high, this is an indication that the circuit was built incorrectly.

2.2 Repeat the previous steps for the following circuit:
2.3 Repeat the previous steps for the following circuit. Note that when the values of resistors are not standard values, you must select the closest possible values.

WRITE A LABORATORY REPORT FOLLOWING THE GUIDELINES FOR LABORATORY REPORTS IN THIS COURSE.