Static Beam Deflection Using LVDT and LabVIEW

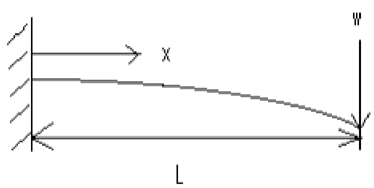
Version: 2.0

Objective:

- Construct a LabVIEW program that compares the theoretical and experimental deflection of a cantilever beam
- To analyze the results and determine the % error between the theoretical and experimental values

<u>Important:</u> In order to do the lab, ask the instructor for the calibration subVI, Cal_Results.vi and LVDT_Calibration.lvm. This subVI is necessary for getting accurate results from the LVDT.

Theory:



$$y = \frac{Wx^2}{6EI}(3L - x)$$

W = Weight applied

x = Location of the deflection

L = Length of the beam

E = Modulus of elasticity

I = Moment of Inertia

y = Deflection

Examining the equation for beam deflection reveals that if weight is added, the beam will begin to deflect. Adding more weight will further increase the deflection of the beam in a linear fashion. For the cantilever beam, assume the Modulus of Elasticity (E) of the steel beam to be **30×10^6 psi**. The moment of Inertia (I) must be calculated yourself.

Before starting the Lab, please be careful of a few things:

- Do not touch the LVDT. Any kind of touching or moving of the LVDT will cause it to give inaccurate results.
- The number that is shown on the display is NOT the voltage that the LVDT is measuring. The correct voltage will be displayed on the VI. If you think that the voltage is wrong on the VI, request a voltmeter from the instructor and measure the voltage that is coming out. Use this to verify that the VI is properly hooked up.
- Do not lift up the beam. Lifting the beam will cause the core to pop out of the LVDT, causing it to lose calibration and causing it to give bad results.

Procedure:

Front Panel:

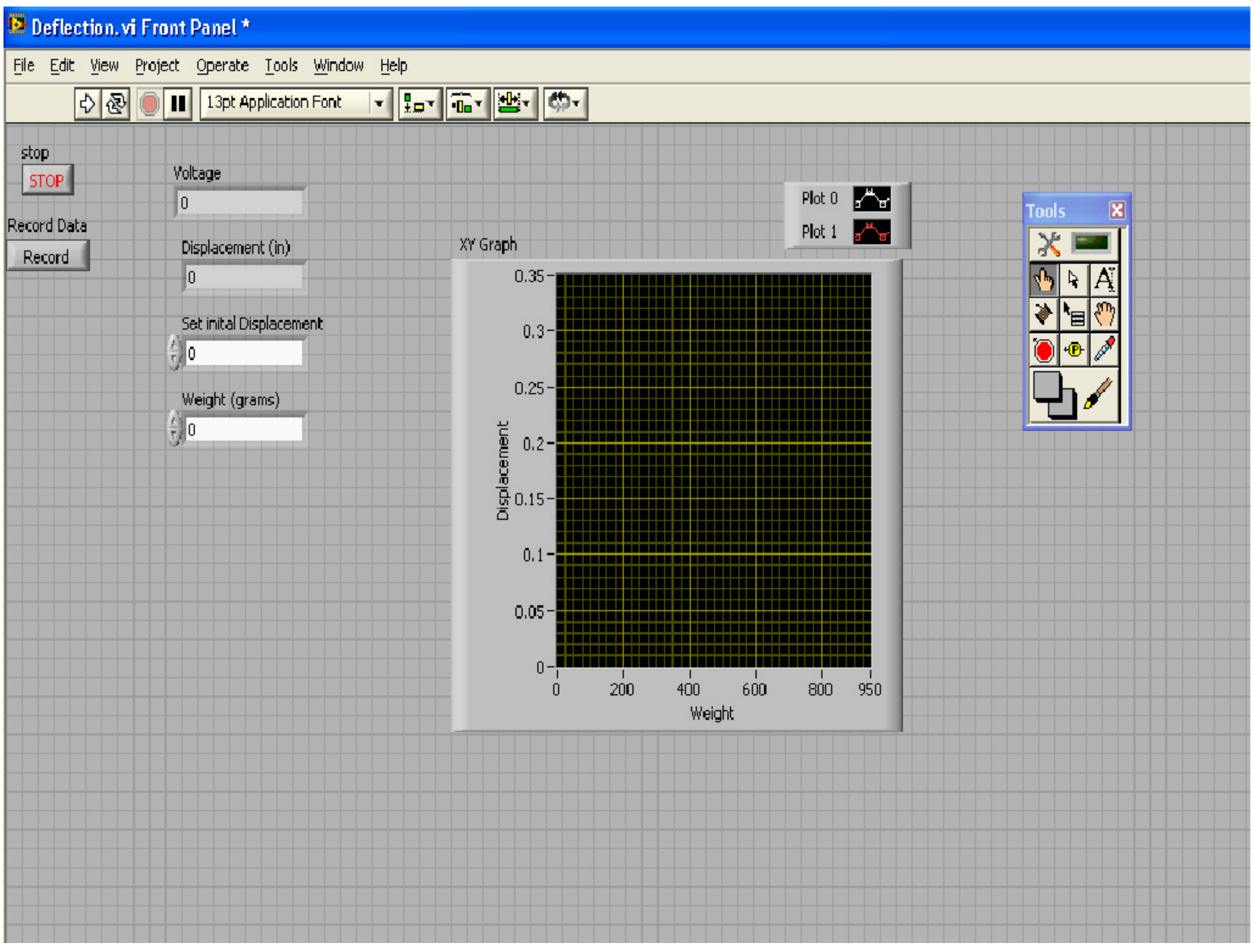


Figure 1 – Front Panel of the Deflection Lab

Reconstruct the Front Panel as shown in figure 1. This includes two Numeric Controls, two Numeric Indicators, and two Boolean buttons. For the two Numeric Controls, label them "Set Initial Displacement" and "Weight (grams)". For the two Numeric Indicators, label them

"Voltage" and "Displacement". Label the units for each to avoid unit confusion later on in the experiment.

Block Diagram:

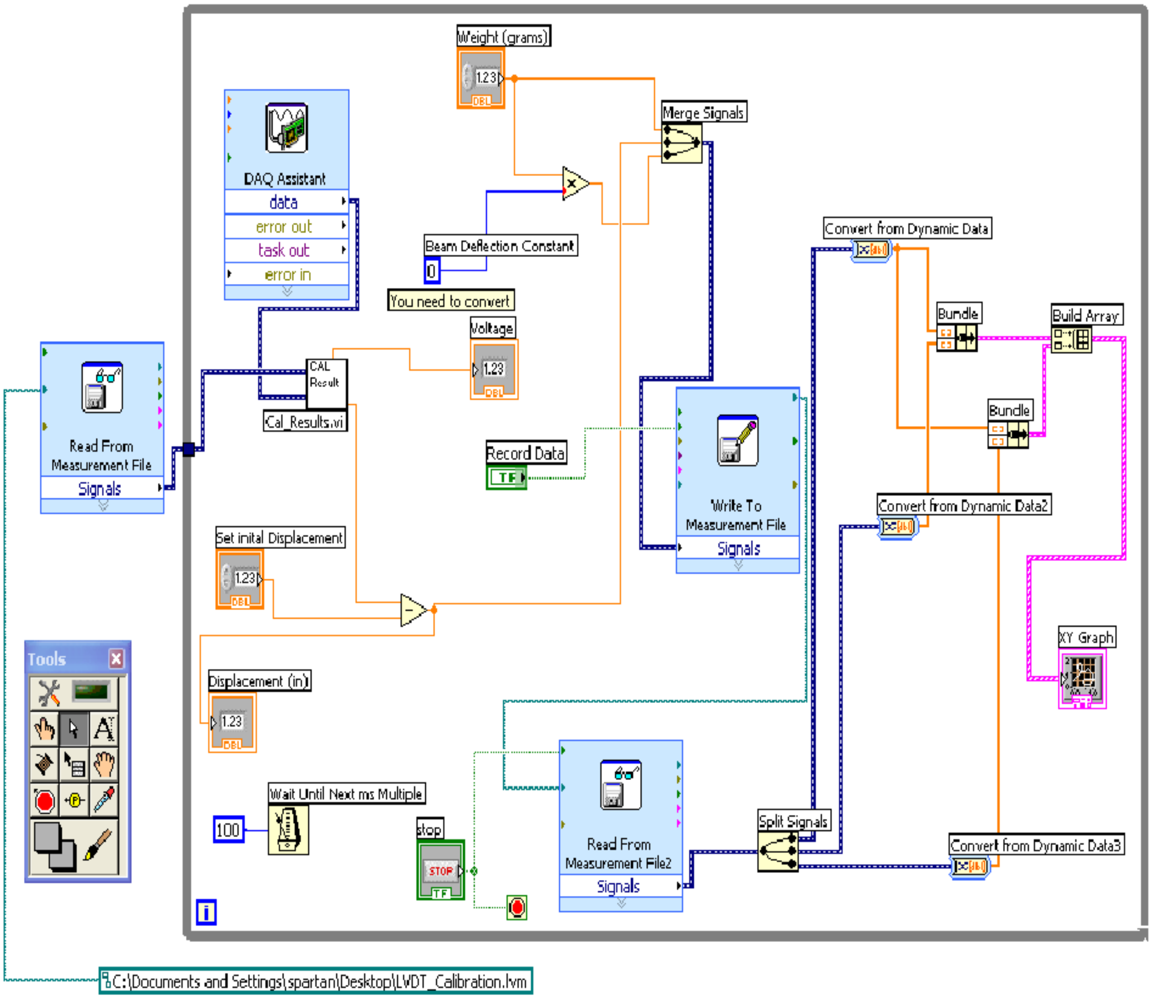
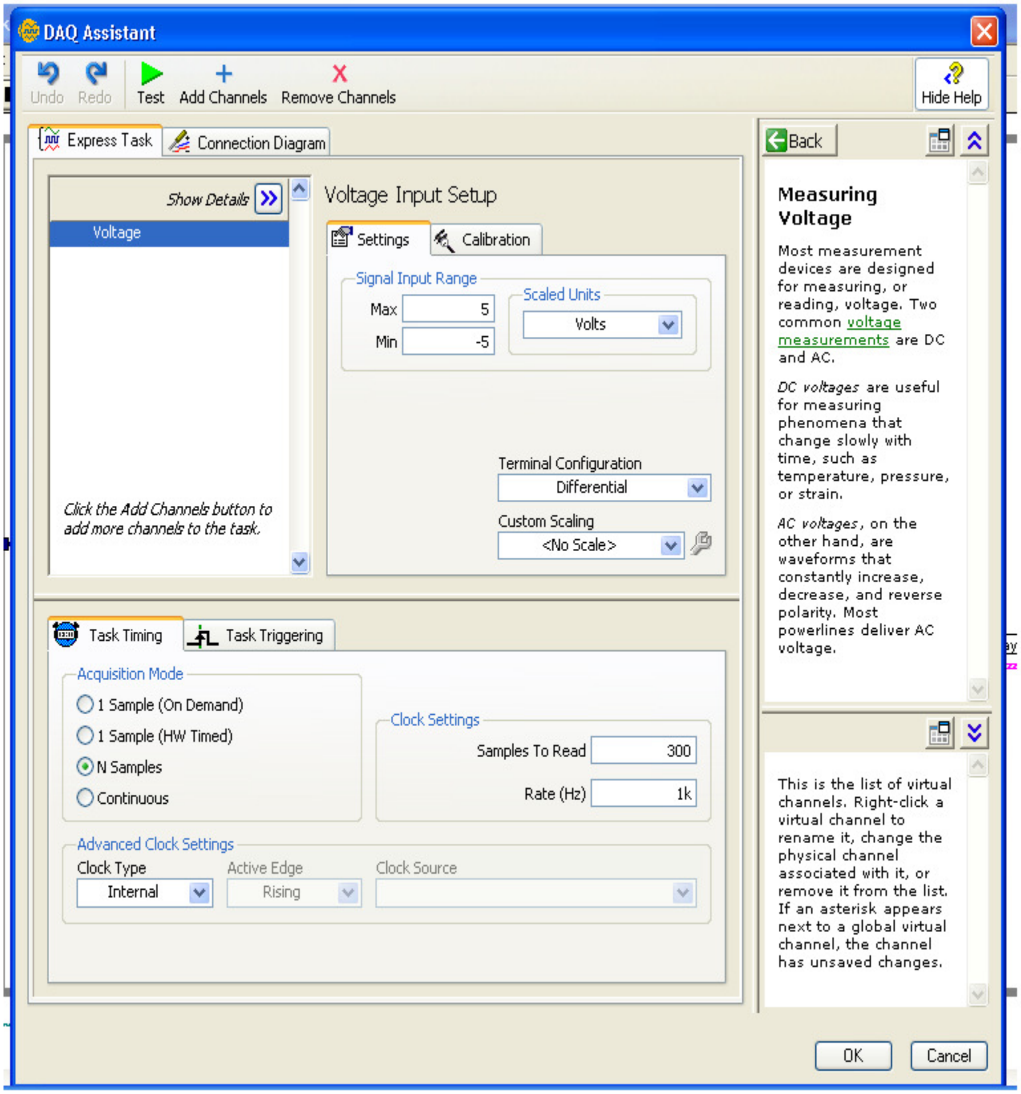


Figure 2 – Block Diagram of the Deflection Lab

Constructing the Block Diagram:

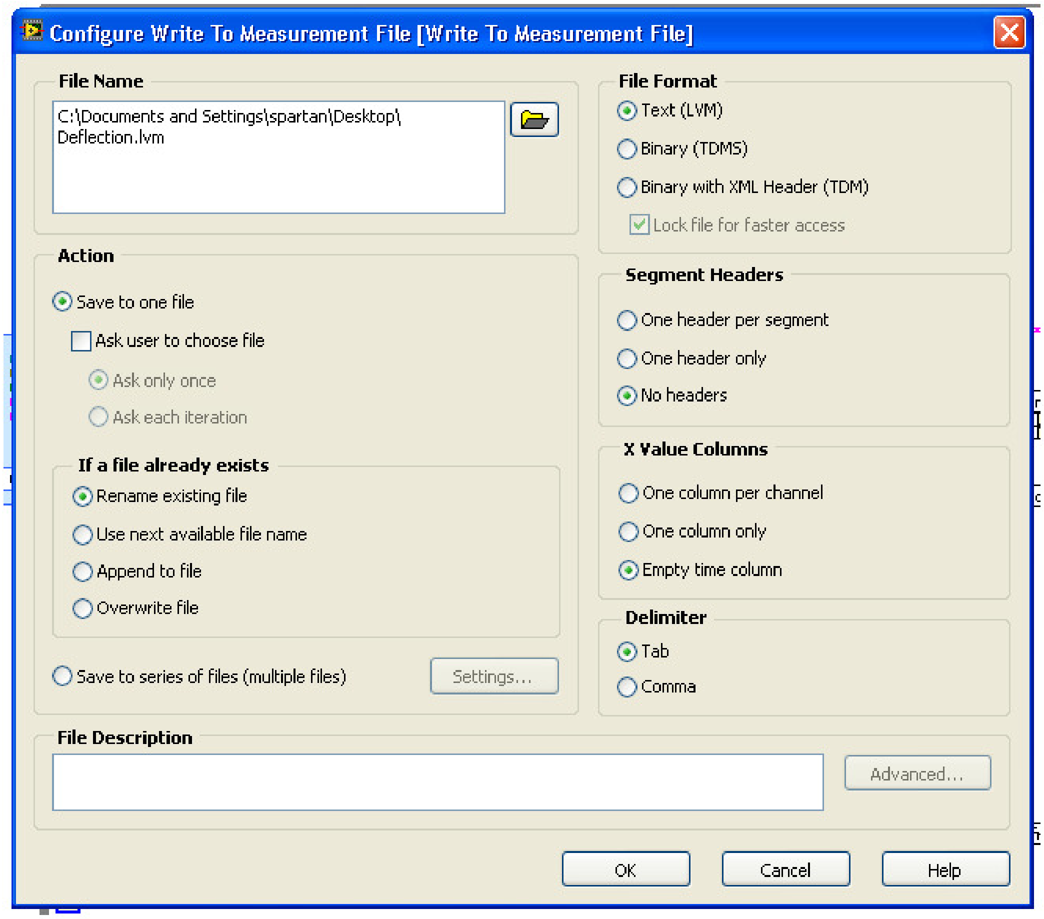
- Create a **While** loop and make sure it is big enough to fit all of the elements inside
- Create the **DAQ Assist** and set the properties:
  - Connect the red wire from the LVDT to channel one of **"Analog In**" on the DAQ board. Then connect the green wire to **ground** on the DAQ board.
  - When you create the DAQ Assist on the block diagram, make sure it is reading input voltage. Set the properties of the DAQ Assist to the following
  - Change the **Clock Setting** to the following

        - Increase the **“Samples To Read”** to **“300”.**
        - Set the **“Rate”** to **“1k”**



- Create the **Read From Measurement File**
    - How to create:
        - Right-click
        - Go to **“File I/O”**
        - Select **“Read Meas File”**
    - In the **File Name**, select the open folder image and select **“LVDT_Calibration.lvm”**. If you don’t have it on the computer, ask the instructor for the file.
    - Keep all defaults and hit OK
- Create the Write To Measurement File
    - How to create:

        - Right-click
        - Go to **"File I/O"**
        - Select **"Write Meas File"**
    - Please note the file name at the top of the window. This file will be created on the desktop (unless changed by the user) and it will save the results from the experiment. You will also need this file name when creating the second **"Read From Measurement File"**.
    - Set the options to the following:



- Create the **2nd Read From Measurement File**
    - In the properties, change the file name to the file name given in the **Write To Measurement File**.
    - Keep the Default settings and hit OK
- Import the subVI **"Cal_Results.vi"** to the block diagram
- Create the **Merge Signals** and **Split Signals**
    - How to create:
        - Right-click
        - Go down to **Express**

        - Select **Signal Manipulation**
        - Select **Merge Signals/Split Signals**
    - To add more nodes, click and drag the box down
- Create **three Convert from Dynamic Data**
    - How to create:
        - Right-click
        - Go down to **Express**
        - Select **Signal Manipulation**
        - Select **"From DDT"**
- Create **two Bundles**
    - How to create:
        - Right-click
        - Select **Cluster & Variant**
        - Select **Bundle**
- Create a **Build Array**
    - How to create:
        - Right-click
        - Select **Array**
        - Select **Build Array**
- Create the appropriate math functions as shown in Figure 2
    - A **multiplication** function
    - A **subtraction** function
- Create a **Wait** function
    - Set the Wait to **100 ms**

Please note the constants that were made, in particular, the Beam Deflection Constant. This number is shown as "0" but in reality, it is a number that you must calculate. If you keep it as "0", only one graph will show up.

Wiring the Block Diagram

- Look at Figure 2 for the appropriate wiring of the Block Diagram
- **IMPORTANT!** Follow the instructions below to properly wire the subVI or else the lab will not work! To see what part of the subVI is which, select the wire tool and hover the mouse over to different corners of the picture. It will show what section corresponds to which part.
    - DAQ: from **Data** -> **Data on the subVI**
    - Read From Measurement File: **Signals** -> **Signals on the subVI**
    - **Voltage on the subVI** -> your **Voltage Indicator**

- **Displacement on the subVI** -> **numerical operation** (the subtraction operation)

Performing the Experiment:

1. Measure the cross section dimensions and the length of the beam. Use this information to calculate its area moment of inertia.
2. Calculate the beam deflection constant which is currently “0” in the block diagram. **HINT:** If you think your beam deflection constant is wrong, look at the units of the Modulus of Elasticity, the units of your moment of inertia, and the units of the weights.
3. Construct the Front and Block Diagrams to the instructions above
4. Hit the Run button on the top to check if the VI works. If it is hooked up properly, you should see a voltage and the initial displacement reading when no weight is applied. This value is being taken in real time so any changes in the beam will be reflected on the numerical indicator.
5. Perform the experiment:
    - You’ll be taking four weight measurements: no weight on the beam, weight of the weight stand (look at the bottom of the stand to see the weight in grams) on the beam, weight stand with one 200g on it, and weight stand with two 200g on it.
    - To get the readings:
        1. Make sure the VI is running
        2. Set the weight your about to test in the numerical control
        3. Click “Record” ONCE to get the voltage and the displacement at that moment. NOTE: to get accurate data, allow the beam to stop oscillating when you add the weights
        4. Repeat 1-3 when the new weights
    - Stop the VI by pressing the STOP button. This will cause two graphs to show up on the Front Panel and create an Excel file with all the data on the desktop with the name given in “Write to Measurement File.”
    - On the graph, the white line represents the results being taking from the LVDT. The red line represents the calculated deflection from the beam deflection constant that you calculated and the weight that was added.
6. Take a look at the Excel file and compare the results. Calculate the % error and possible reasons for error if any in you report.