

## WorkPower Build

This guide walks the reader through building a Virtual Instrument, VI, using LabVIEW. This VI displays graphs of Work and Power for selected Force and Distance values.

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Thank you for reviewing this document and providing any feedback.

Warm regards,

Eric Mann

## Building WorkPower VI

This guide walks the reader through building a Virtual Instrument, VI, using LabVIEW. This VI displays graphs of Work and Power for selected Force and Distance values using the formulae

$$W = Fd \text{ and } P = \frac{W}{t} .$$

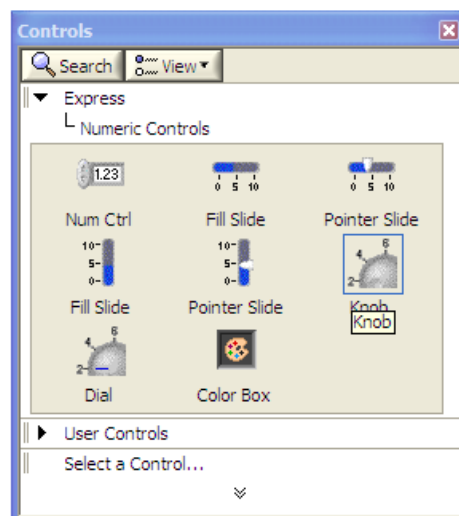
The Work graph will be a horizontal line showing that work is constant when force and distance are held constant, while Power is Work/time.

- 1) Create a new VI by selecting **File»New VI** or pressing **<Ctrl-N>**

The **<Ctrl>** key in keyboard shortcuts corresponds to the **(Mac OS)** **<Command>** key or **(Linux)** **<Alt>** key.

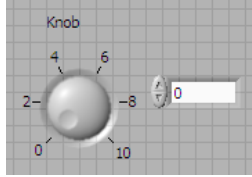
### Create the Front Panel

- 2) Add a numeric control to the front panel
  - a. Right-click on the front panel to open the **Controls** palette
  - b. Tack the **Controls** palette down by clicking the thumb tack in the upper right hand corner of the palette
  - c. Select **Knob** from **Express»Numeric Controls**
  - d. Click on the front panel to place the control



**Figure 1.** The Controls palette

- 3) Add a digital display for the knob
  - a. Right-click on the knob to open the context menu
  - b. Select **Visible Items»Digital Display**



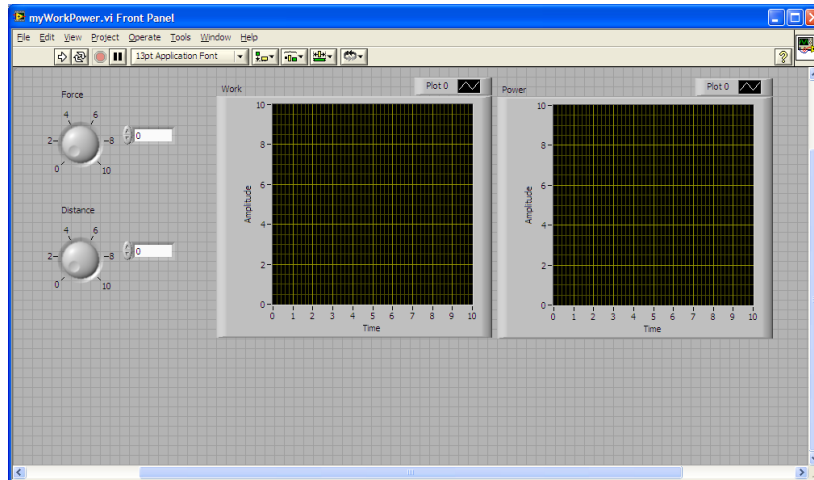
- 4) Make a copy of the knob
  - a. Hover the mouse over the control until the cursor becomes an arrow (This is the position/size/select tool.)
  - b. Click on the control to select it
  - c. Select **Edit»Copy** or press <Ctrl-C>
  - d. Click on the front panel and select **Edit»Paste** or press <Ctrl-V>
- 5) Name the controls
  - a. Triple-click the label of each control to highlight the text
  - b. Name the controls “Force” and “Distance”

Next, you will add **XY Graphs** to the front panel. These indicators will be used to display the graphs of Work and Power with respect to time.

- 6) Add an **XY Graph** to the front panel
  - a. Click on the double arrows at the bottom of the **Controls** palette
  - b. Select **XY Graph** from **Modern»Graph**

Be sure to use the **XY Graph** from the **Modern** subpalette. The **Express XY Graph** in the **Express»Graph Indicators** palette is not the same indicator.

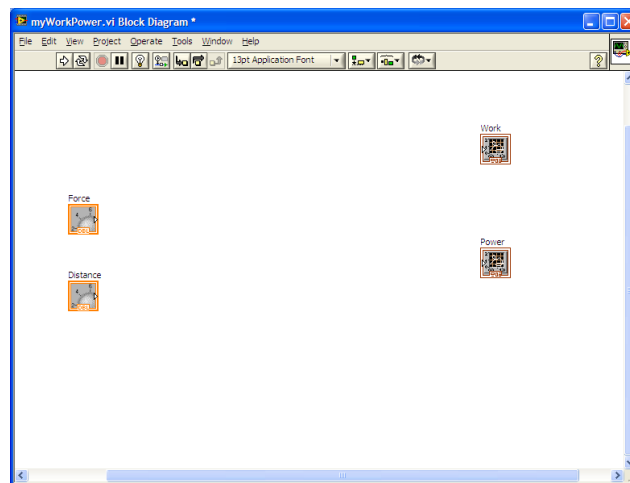
- c. Click on the front panel to place the graph
  - d. Change the label of the graph from “XY Graph” to “Work”
- 7) Add a second **XY Graph** to the front panel
  - a. Change the label of the graph from “XY Graph” to “Power”
  - b. If necessary, resize the front panel to accommodate the second **XY Graph**
- 8) Save your VI
  - a. Select **File»Save** or press <Ctrl-S>
  - b. Call the VI **myWorkPower**



**Figure 2.** The beginnings of the front panel

You will add code to the VI to use these values to calculate Work and Power. The block diagram of a VI displays the code that executes when the VI is run. So far, the block diagram has only four items on it – two orange icons for the Knobs and two brown icons for the graphs.

- 9) Select **Window»Show Block Diagram** or press <Ctrl-E> to view the block diagram
- 10) Arrange the icons as shown below



**Figure 3.** The beginnings of the block diagram

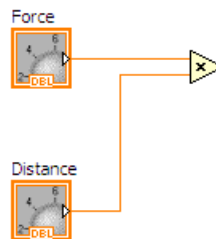
### Create a Graph for Work Done over Time

Work is the product of force and distance. Multiplication is easy to add to the VI.

- 11) Add a **Multiply** VI to the block diagram
  - a. Right-click on the block diagram to open the **Functions** palette
  - b. Tack the **Functions** palette down by clicking the thumb tack in the upper left corner of the palette

- c. Click on the double arrows at the bottom of the **Functions** palette to expand the menu
  - d. Select **Programming»Numeric»Multiply**
  - e. Click on the block diagram to place the VI
- 12) Connect **Force** and **Distance** to the **Multiply** VI
- a. Wire the terminal of **Force** to the first input of the **Multiply** VI
  - b. Wire the terminal of **Distance** to the second input of the **Multiply** VI

To wire the components together, hover the mouse over the terminal of the array until the wiring tool appears. Then, hold down the left mouse button and drag the cursor to the destination terminal. When the terminal appears, release the mouse button to connect the wire.



**Figure 4.**  $W = Fd$

The output of the **Multiply** VI will have the amount of work for the given force and distance. You will use this value to create a graph of work and power.

LabVIEW has built-in VIs for evaluating a function entered as text. You can use these VIs to evaluate functions for given values of  $x$ , or  $t$ . What functions are you evaluating? Well, there are two. The function you will use first is for Work,  $W = Fd$ . This function is constant with respect to time. Once values for force and distance are selected, work is simply their product.

The other function, Power, is not constant. From the formula,  $P = \frac{W}{t}$ , it is clear that as the amount of time changes, the power will change as well. You will use this function when you set up the VI to graph Power over time.

Before adding the VIs to evaluate your functions, you will create a string of text to represent the formulae. LabVIEW has tools for turning numeric data into string data, or text. You will use one of these tools to create your functions.

- 13) Add **Format Into String** to the VI
  - a. Select **Programming»String»Format Into String**
  - b. Click in the middle of the block diagram to place the VI
- 14) Use **Context Help** to understand the VI
  - a. Hover the cursor over the **Format Into String** VI
  - b. Press <Ctrl-H> to open the **Context Help** and see what this VI does

The <Ctrl-h> keys in keyboard shortcuts correspond to the (Mac OS) <Shift-Command-h> keys.

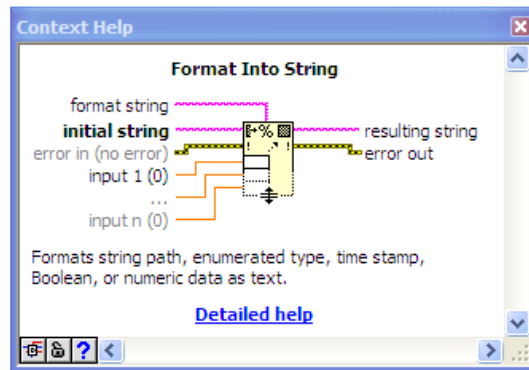


Figure 5. Context Help

- c. Click on the link to detailed help from the **Context Help** for **Format Into String**
- d. Review the help information to get a sense of what the VI does

You will format the numeric data into string data using the **Format Into String** VI. To do this, you will create a template for how to handle the numeric data. In the case of work, you will simply convert the number into text.

- 15) Right-click the **Format Into String** VI and select **Edit Format String** from the context menu to create and edit the template
  - a. Use the **Edit Format String** window to build the expression, “%.6f”

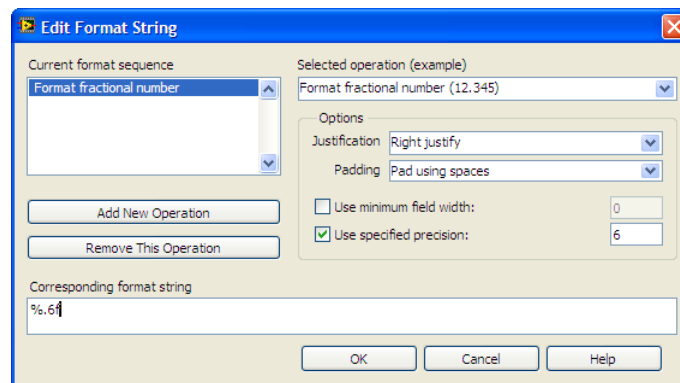


Figure 6. Edit Format String window

- b. Click OK to close the **Edit Format String** window

The **Format Into String** VI will now have a terminal for a numeric input (DBL in orange). It will also have a pink input for the **format string**.

- 16) Use the Wiring tool to connect the output of **Multiply** to the numeric input of **Format Into String**

17) Save your VI, <Ctrl-S>

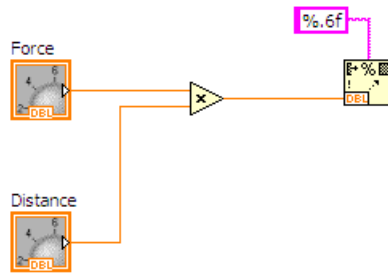


Figure 7. Work input to the **Format Into String** VI

The output of the **Format Into String** VI is simply the amount of work as string data, i.e. text. This string can be used as an input for an evaluation VI to create an array of data that can in turn be plotted on a graph. If this sounds confusing, all we are doing is building a table of x and y values in order to graph.

- 18) Add **Eval y=f(x).vi** to the block diagram
- Select **Eval y=f(x).vi** from **Mathematics»Scripts & Formulas»1D & 2D Evaluation** on the **Functions** palette

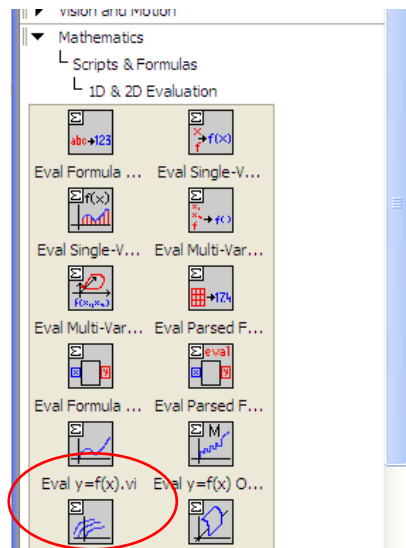
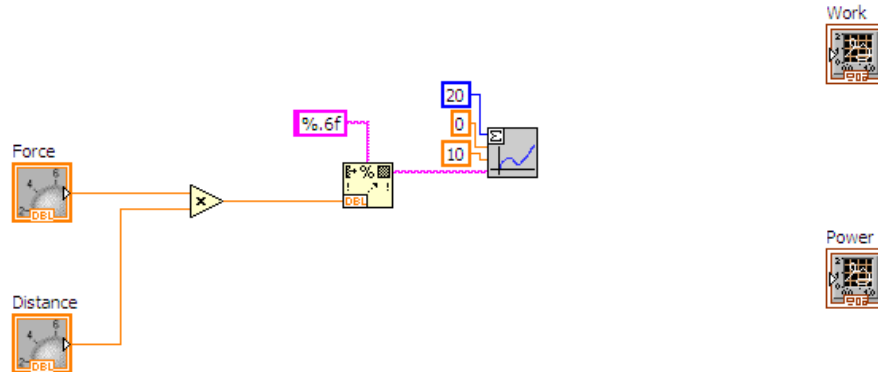


Figure 8. 1D & 2D Evaluation palette

- Click on the block diagram to place the VI to the left of the **XY Graphs**
- 19) Use **Context Help**, <Ctrl-H>, to understand the **Eval y=f(x).vi**
- 20) Use the Wiring tool to connect the **resulting string** output of the **Format Into String** VI to the **formula** input of **Eval y=f(x).vi**
- 21) Connect other inputs to **Eval y=f(x).vi**
- Right-click on the **start** terminal of the VI, select **Create»Constant**, and set the value of the constant to 0

- b. Right-click on the **end** terminal of the VI, select **Create»Constant**, and set the value of the constant to 10
- c. Right-click on the **number of points** terminal of the VI, select **Create»Constant**, and set the value of the constant to 20



**Figure 9.** Evaluation VI added to block diagram

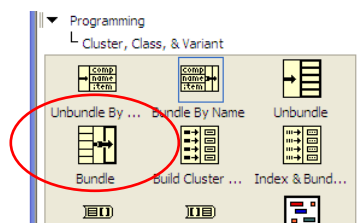
The **Eval  $y=f(x)$ .vi** evaluates the **formula** for a set of  $x$ -values between the **start** and **end**. The VI outputs both a set of  $x$ -values and  $y$ -values. These sets are limited by the use of 0 and 10 for the **start** and **end** values. (It is possible to capture the X Scale minimum and maximum and use those for **start** and **end**. To do so, requires the use of **Property Nodes**, an advanced topic left for another time.)

The sets of values created by **Eval  $y=f(x)$ .vi** are arrays. The **XY Graph** uses both of the arrays to graph the function. To connect the two arrays to the **XY Graph**, you will bundle them together in a cluster.

A cluster is like an array in that it can hold multiple items of value. The two types differ in that a cluster can hold multiple data types, while an array holds multiple elements of a single data type.

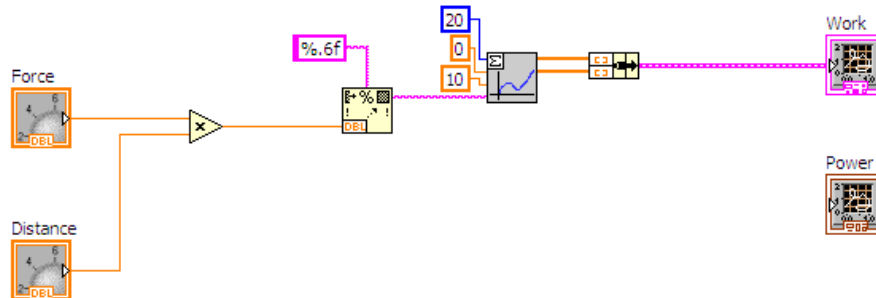
22) Bundle the  $x$  and  $y$  arrays into a cluster

- a. Select **Programming»Cluster, Class, & Variant»Bundle** and click on the block diagram to place the VI
- b. Connect the **X values** output of the **Eval  $y=f(x)$ .vi** to the first element of **Bundle**
- c. Connect the **Y values** output of the **Eval  $y=f(x)$ .vi** to the second element **Bundle**



**Figure 10.** Bundle VI on the Cluster, Class, & Variant palette

- 23) Wire the output of the **Bundle VI** to the **XY Graph**
  - a. The XY Graph will change from brown to pink to denote its data type as a cluster of numeric arrays
- 24) Save your VI, <Ctrl-S>

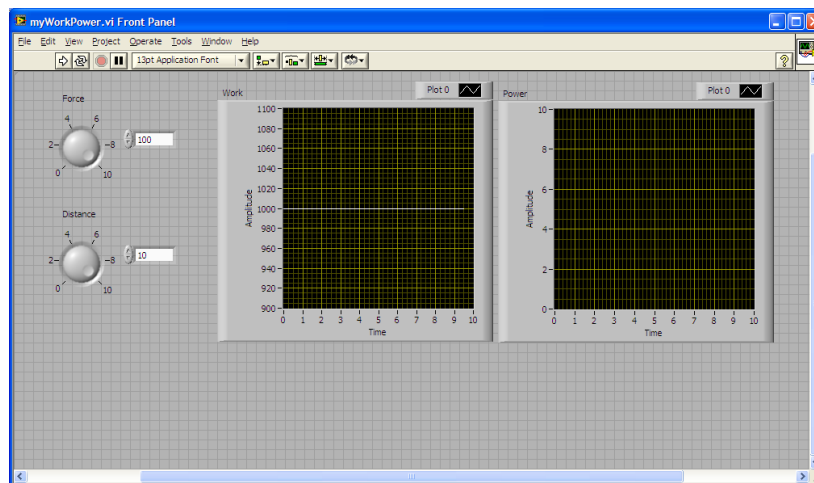


**Figure 11.** Data wired to the Work graph

Next, let's see how the VI runs.

- 25) Return to the front panel by selecting **Window>Show Front Panel** or pressing <Ctrl-E>
- 26) Use the controls to enter values for **Force** and **Distance**
- 27) Run the VI by pressing the **Run** button or by pressing <Ctrl-R>

You can run the VI using the **Run Continuously** button as well. Running continuously will have the code in the block diagram executed over and over again. To stop the execution, use the **Abort Execution** button.

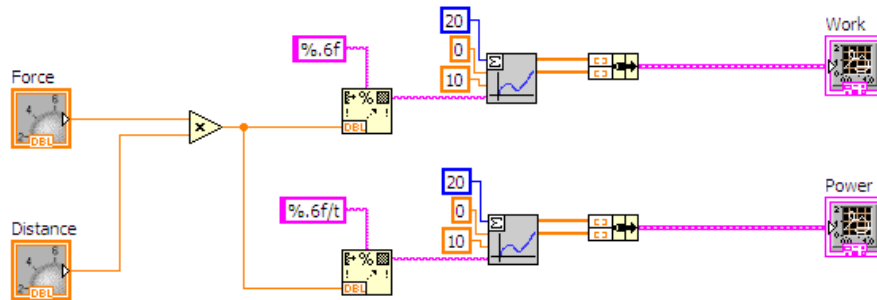


**Figure 12.** A graph of work displayed

Are you surprised by the graph? The amount of work done does not depend on how long the work takes. Therefore, the graph will be a horizontal line. Work is the same whether it takes 1 second or 10 seconds.



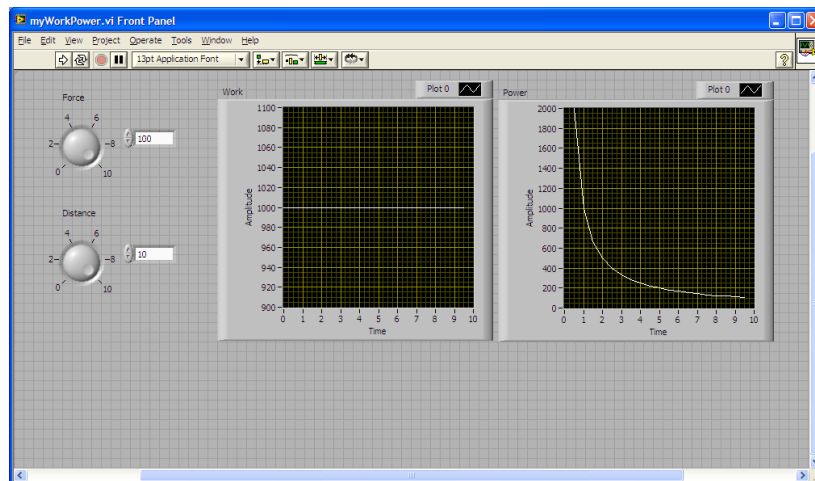
- c. Right-click on the **number of points** terminal, select **Create»Constant**, and set to 20
- 35) Bundle the  $x$  and  $y$  arrays from **Eval  $y=f(x)$ .vi** into a cluster
- a. Select **Programming»Cluster, Class, & Variant»Bundle**
  - b. Connect the **X values** to the first element of the **Bundle VI**
  - c. Connect the **Y values** to the second element of the **Bundle VI**
- 36) Wire the output of the **Bundle VI** to the **Power** graph
- 37) Save your VI, <Ctrl-S>



**Figure 14.** Data connected to Power graph

Next, let's see how the VI runs.

- 38) Return to the front panel by selecting **Window»Show Front Panel** or pressing <Ctrl-E>
- 39) Use the controls to enter values for **Force** and **Distance**
- 40) Run the VI by pressing the **Run** button or by pressing <Ctrl-R>



**Figure 15.** Work and Power displayed in front panel

The WorkPower VI is complete. Of course, more customization is possible. You could resize the graph or the front panel itself. Also, right-click on any of the controls or indicators to see what else could be made visible or what properties could be changed. Many display options are configurable.