General Physics I Lab

M1 The Atwood Machine

Purpose

In this experiment, you will learn the basic operation of computer interfacing and use it in an experimental study of Newton's second law.

Equipment and components

PASCO 550 Universal Interface, Smart pulley, mass set, hanger (x2), stand and clamp, cushion, thread.

Background

Computer interfacing consists of three main components: sensors, an interface box (hardware) and a control program to be run in a host computer (software). Measuring devices with an electronic output are called **sensors** and they are used to measure and output the data to the **interface box** (*PASCO 550 Universal Interface*). The interface box collects and converts the data from the sensors and output them to the host computer. To display, manipulate and analyze the data, a computer **interface program** (*PASCO Capstone*) is used. Computer interfacing allows us to collect large amounts of data with high speed and accuracy. Nowadays, most physics research experiments use computer interfacing.

In the following, we give a brief introduction to the hardware and software to be used in the experiment. Please refer to the "Help" menu of the *PASCO Capstone* program for more details.

Starting a new experiment

In the experiment to be carried out below, the basic control program has been written up for you, and you may start the experiment by running the program right away. However, it is strongly recommended that you understand the basic operation of the computer interfacing.

1. Connect the *PASCO 550 Universal Interface* to the computer. Turn on the interface and the computer.
2. Double-click the *PASCO Capstone* icon to start the program.
3. A new experiment setup window (*PASCO* calls it "workbook") will display as shown in Figure 1. The main features are:
   i. **Menu and Toolbar** includes common application functions, such as file open and save, undo, help, and application specific functions, such as display settings, and journal. Some functions are available as toolbar buttons.
   ii. **Page Tools** includes tools to add pages, change page properties, and edit the master page.
   iii. **Tools Palette** includes tools to add interfaces and sensors, the data sets and ability to edit data properties (unit of measure, run names etc.), calibrate sensors, define calculations, define curve fit parameters, set up signal generators, and set up timers.
   iv. **Controls Palette** is used to start/stop data collection, set the data monitoring mode, set the sampling rate, delete data runs, define Start/Stop conditions, and playback synchronized video.
   v. **Displays Palette** is used to add displays to workbook pages. Displays can be added by double clicking or drag and drop using QuickStart templates or drop targets.
   vi. **Display area** in the *PASCO Capstone* Workbook pages facilitate quick and easy layouts and support highly flexible page designs.

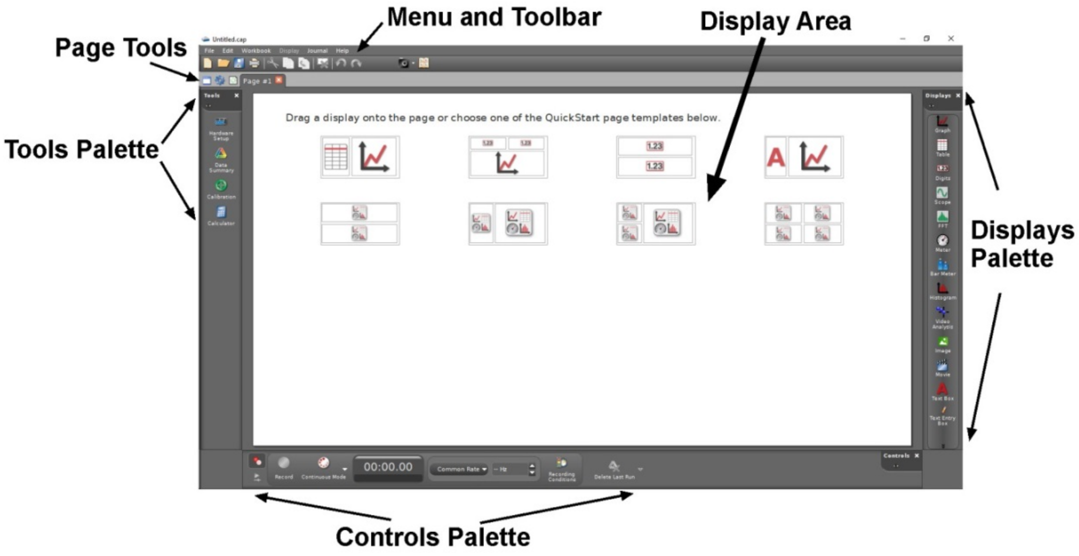


Figure 1 New experimental setup window

4. Physically connect the sensor(s) to the interface box by plugging the connector of the sensor(s) to the appropriate channel(s). For the *PASCO 550 Universal Interface*, there are three types of sensors: PASPORT, digital and analogue.
5. Add the sensor(s) in *PASCO Capstone*:
   a. Click the **Hardware Setup** in the Tools Palette;
   b. Click within the yellow circle of the channel to add a sensor;
   c. Select the sensor to add from the drop down list
6. Click the “Properties” icon of the sensor to *view and setup the sensor properties*.
7. Click one of the display icons in the Display Palette and drag the icon to the Display Area.
8. The setup is ready now. Click the “Record” button in the Controls Palette to *start data recording* all available data. The “Record” button toggles to “Stop” button, click the “Stop” button to stop data collection.

Data export

You may export any data set in *PASCO Capstone* to a text file (*.txt) by:

1. On the “File” menu, click “Export Data …”.
2. Select the data set(s) in the **Export Data** window, the data set(s) will be shown as column(s) in table form.
3. Click the “Export to file…” button at the right bottom corner. Navigate to the desired folder and type a name. Click “Save”. Then the data will be saved in a text file (*.txt) for a later use.

Graph export

You may export the Graph display in *PASCO Capstone* by:

1. Click and select the Graph display window that you want to export.
2. On the “Display” menu, click “Copy Display”.
3. Open a Microsoft Word document, right-click and select Paste (or Ctrl-V). The Graph display will be shown. **Note:** It is highly recommended that you should paste two graphs on one page **BEFORE** printing.

Display

The following is a list of useful displays with annotation, which may serve as a quick reference for you to select the desirable display.

1) Graph

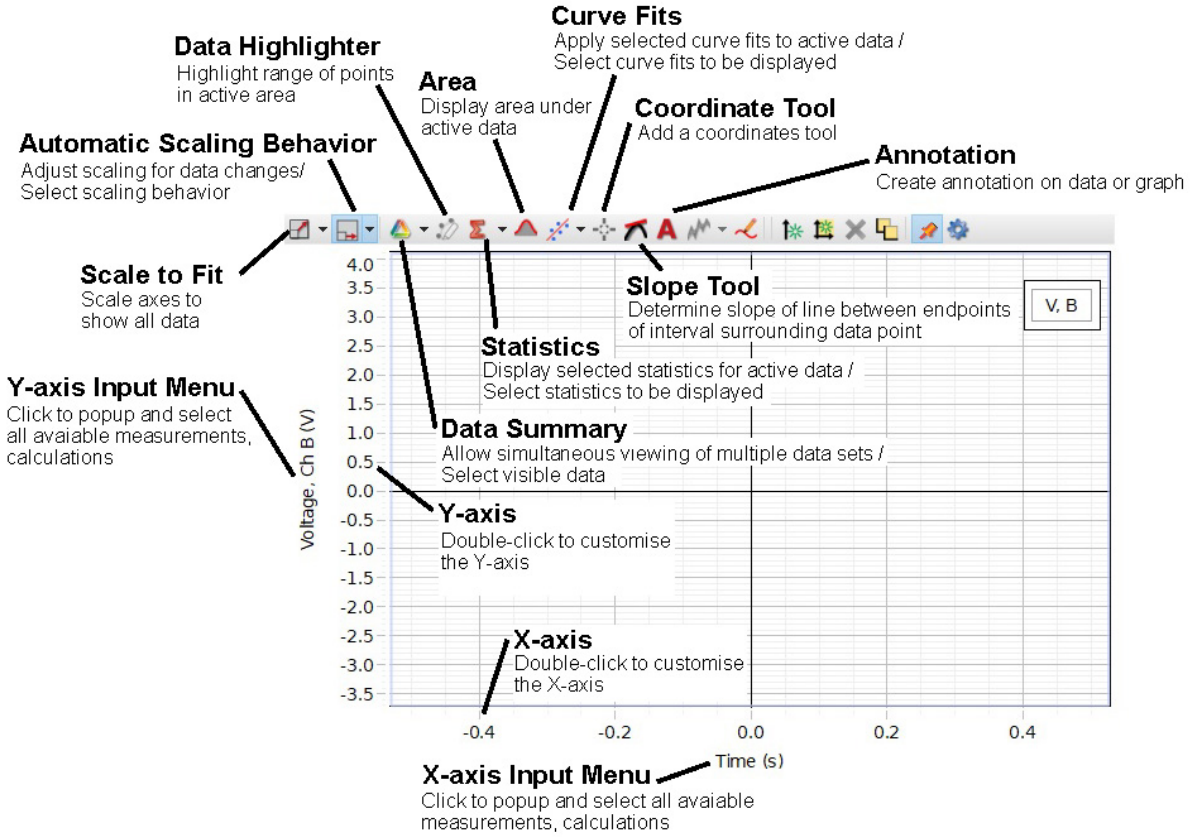


Figure 2 Graph Display

2) Table

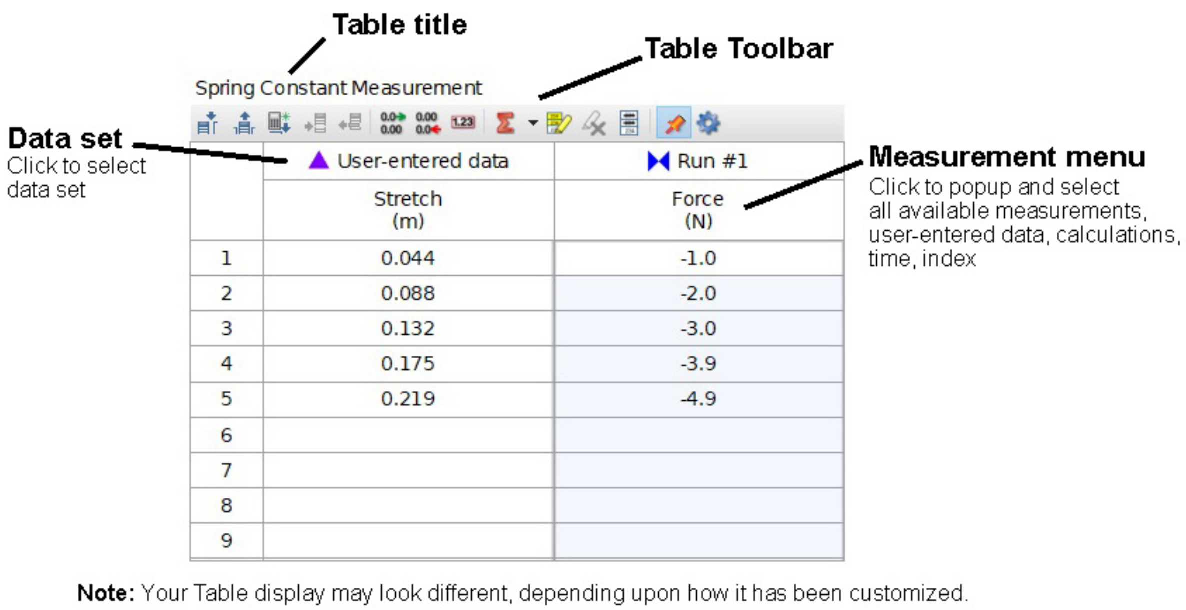
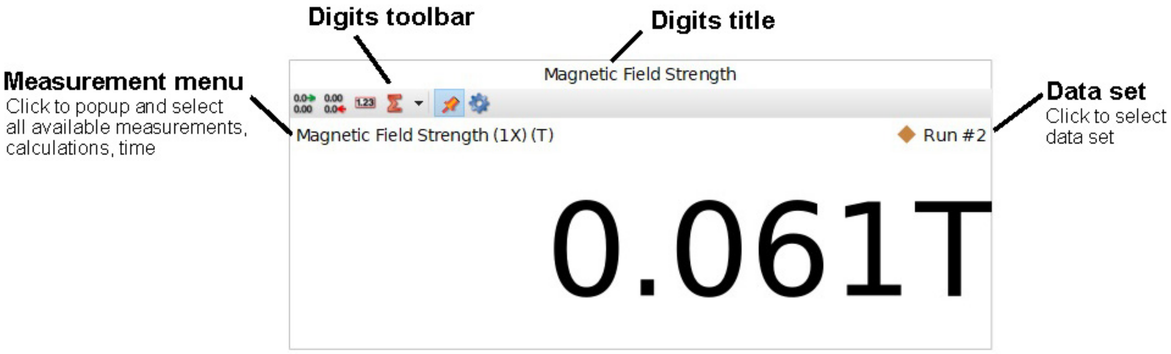


Figure 3 Table Display

3) Digits



Note: Your Digits display may look different, depending upon how it has been customized.

Figure 4 Digits Display

Procedure

In this experiment, the Smart pulley is used to measure the motion of two hanging masses as one moves up and the other moves down. The two masses have different weights and are connected by a thin string. The *PASCO Capstone* program calculates the changing speed of the masses as they move. A graph of speed versus time reveals the acceleration of the system.

Computer setup

1. Connect the *PASCO 550 Universal Interface* to the computer. Turn on the interface and the computer.
2. Connect the stereo phone plug of the Smart pulley to Digital Channel 1 on the interface.
3. Open the "M1" program in the course folder. The program will open with a graph display of Linear Speed (m/sec) versus Time (sec).

Experimental setup (as shown in Figure 5)

1. Place the stand and clamp near the edge of the table. Mount the Smart pulley in the clamp so that its holding rod is horizontal.
2. Put a cushion (foam or plastic air bag will be provided) on the floor under the Smart pulley.
3. Use a piece of thread about 10 cm longer than the distance from the top of the pulley to the floor. Place the thread in the groove of the pulley.
4. Fasten a mass hanger to each end of the thread by wrapping the thread four or five turns around the notched area of the mass hanger.
5. Place ~100 grams of mass on one mass hanger and record the total mass as M_1 in Table 1. Be sure to include the mass of the mass hanger in the total mass. Place slightly more than 100 grams on the other hanger. Record this total mass as M_2.

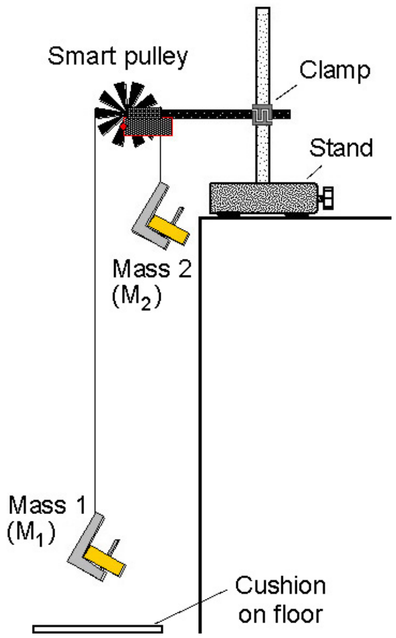


Figure 5 Experimental setup

6. Move the heavier mass (M_2) upward until the lighter mass (M_1) almost touches the floor. Hold the heavier mass to keep it from falling. Rotate the pulley so that the infrared light beam from the photogate is unblocked. In this case, the red LED (light-emitting diode) indicator on the photogate is off (no light).

Part I. Constant total mass

1. Click the “Record” button in the Controls palette. Let the heavier mass fall. Data recording will begin when the infrared light beam from the photogate is blocked and the red LED indicator is on.
2. Click the "Stop" button to end data recording just before the heavier mass reaches the floor. Make sure that the upward moving mass does NOT hit the Smart pulley! **NOTE:** *The two masses may collide, as one descends and the other rises. Please have another data run if this happens.*
   - “Run #1” will appear when the pull-down arrow next to the **Data Summary** in the toolbar is clicked.
3. Rescale the graph to display all the data points and then zoom in the portion of the curve you want to study in details.
4. On the Graph display, click **Data Highlighter** icon in the toolbar (a rectangular highlighter box appears on the graph that is the same color as the data points). Enclose the data of the accelerating part by : i) Click and drag the highlighter to move it; ii) Click and drag the handles to resize the highlighter. NOTE: Selected data is highlight in yellow.
5. Use the **Curve Fits** tool of the Graph display to determine the experimental acceleration, a_{exp}, and record its value in Table 1 by:
   a. Click to depress Curve Fits icon in the toolbar ;
   b. Click the pull-down arrow next to Curve Fits to select the curve fit that you wish to apply to the selected data.
6. Export and print the linear speed versus time graph together with the curve fitting and paste it in the lab report. **NOTE:** *Resize the graph to a suitable size before printing them.*
7. Change the ratio of M_1 to M_2 by removing a mass from one hanger and adding it to the other. This allows you to change the net force without changing the total mass.
8. Repeat steps 1-3 for two more different values of M_1/M_2. Record the values of M_1 and M_2 for each combination. Change the net force each time but keep the total mass constant. Record all the experimental values and complete the calculated values in Table 1.

Part II. Constant net force

1. Arrange the masses as they were at the beginning of Part I. Now, change the total mass but keep the net force the same as that in the first run of Part I. To do this, you need to add exactly the same amount of additional mass to both mass hangers. Make sure that the difference in mass remains the same as it was at the beginning of Part I.
2. Record the new values of M_1 and M_2 in Table 2.
3. Take the data as in steps 1 – 5 in Part I.
4. Repeat above two steps for two more times with a different value of the total mass each time but keeping the net force *constant*. Record all the experimental values and complete the calculated values in Table 2.
5. Export the linear speed versus time graph together with the curve fittings (including all three sets of data). To display multiple runs:
   a. Click to depress **Data Summary** icon in the toolbar ;
   b. Click the pull-down arrow next to **Data Summary** to select more runs to display.
6. Paste the graph in the lab report. **NOTE:** *Resize the graph to a suitable size before printing them*