The procedure for using the parameter analyzer to measure BJT characteristics is nearly identical to the diode measurements done early. The main difference is that the BJT has an extra terminal, giving an extra variable to control.

There are several different types of measurements that can be done. Initially, we will stick with the simple $i_C - v_{CE}$ characteristics that are the standard way of representing the behavior of a transistor. The analyzer has a canned program for doing this particular measurement.

The emitter of the transistor will be the ground connection (SMU 1 in the canned program). The base *current* is controlled using SMU 2 and the collector *voltage* is controlled with SMU 3. The collector voltage will be Variable 1 and the base current will be Variable 2. The program starts by setting the base current at the initial value and then stepping through all of the collector voltages, measuring the collector current at each step. Then the base current is changed to the next value and the collector voltage steps through the range of values again, measuring current at every step. This continues for all of the values of base current defined in the measurement set up. Conceptually, this like using nested "do loops" when writing a computer program.

Since we have used the analyzer previously, we won't describe each step in detail. As with the diode there are 5 basic steps: 1) physically connect the device to the analyzer, 2) define the function of the SMUs (channel definition page), 3) set up the voltages and currents to be used (sweep setup page), 4) set up the axes for the graph (display setup page), and 5) perform the measurement and observe the results (graph/list page).

1. Connect the transistor to the analyzer. There is a special connector that can be used for discrete transistors. However, it is probably easiest to plug the BJT into a breadboard and use the small wires to connect to the analyzer: emitter --> SMU 1, base --> SMU 2, and collector --> SMU 3.

2. Go to the Channel Definition page. Press the softkey labeled "MEM1 B-Tr VCE-IC" to bring up the canned BJT program. You should see that SMU 1 (the emitter) is defined as a constant and is labeled COMMON. SMU 3 (the collector) is defined as a voltage source, so it will set voltages and measure currents. It is labeled as VAR1. SMU 2 (the base) is configured as a current source, so that it will set currents. It is labeled as VAR2.

3. Go to the Sweep Setup page. For VAR 1 (collector) set the start voltage at 0 V, the stop voltage at 10 V, and the step size at 0.1 V. The compliance can be 100 mA. (The 2N4400 can handle this amount of current easily.) For VAR 2 (base) set the starting current at 10 μA, the step size to 10 μA, and the number of steps to 7. (For some reason the parameters for VAR 1 and VAR 2 are entered slightly differently.) The compliance for the base can be 2.0 V. For both variables, the SWEEP MODE should be SINGLE and the LIN/LOG option should be LINEAR. Also on this page, be sure to set the *SWEEP setting to "CONTINUE AT ANY".

4. Go to the Display Setup page. The graph should already be defined to have VCE on the x-axis and IC on the y-axis. Set the limits for the x-axis to have a minimum of 0 V and a maximum of 10 V. Since we can't know what the currents will be until after we have taken some data, there is no need to change the y-axis limits. We will use auto-scaling after the measurement is complete.

5. Go to the Graph/List page. You should see an empty graph, just waiting for some data to plot. Press the "Single" button to start the measurement. (The green measurement will light until the measurement is complete. It may take a minute or so.)

6. Once the measurement is finished, press the "SCALE" softkey at the bottom and then "AUTO SCALE" softkey on the upper right side. There should be a nice set of i_C-v_{CE} curves displayed on the graph.

7. If you would like to get some numbers so that you can calculate the current gain, press the "CURSOR/MARKER" softkey at the bottom of the screen and then press the "MARKER" softkey on the right side. This puts a maker on the graph. You can move the marker to different points on the graph using the small scroll wheel to the right of the display. As scroll the marker around, the voltage and current of the marker are displayed near the top of the screen. If you want to look at numbers from some of the upper curves, you can use the "MARKER SKIP" soft key to make the marker skip from one curve to the next, saving a bit of scrolling time. If you put the marker on a forward active portion of the one curves, you can read the collector current directly, and since you know the value of base current for that curve, you can calculate β_F easily.

8. Don't forget to take a photo of the set of curves for your report.