

EXPLORATIONS

Activity 5

Collecting Data

Topic 19 shows how to use random numbers to collect samples (from which data is obtained) and how to randomly assign subjects to experiments to collect data.

Topic 20 gives an example of how the TI-83, along with the Calculator Based Laboratory™ (CBL™) System, can be used to collect data dynamically (in real time).

Topic 19—Random Sampling and Randomization for Experiments

The following table represents a class of 24 students with 15 females and 9 males.

1 *	2	3	4 *	5	6
Bertha F1	Joe M1	Kay F2	Flora F3	Kojo M2	Bernice F4
7 *	8	9	10	10	12
Marge F5	Barbara F6	Jim M3	Narissa F7	Walter M4	Shaine F8
13 *	14	15 *	16	17	18 *
Ann F9	Frank M5	Chris M6	Esi F10	Shirley F11	Cheyenne F12
19 *	20	21	22	23	24 *
Tom M7	Pete M8	Ruby F13	Max M9	Linda F14	Mary F15

Activity 5, Collecting Data (cont.)

Random Sampling

Simple Random Samples

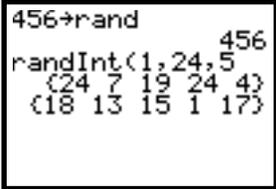
1. To select a committee of eight students with each student having an equal chance of being selected, give the student an identification number (use the numbers 1 to 24 above the students' names in the table).
2. Set a seed for the random-number generator. (This is done so you can duplicate the results in this handbook. If that is not important to you, then there is no need to set the seed.)

If you wish your seed to be different from others, the last four digits of your Social Security Number should work.

3. Type **456** **[STO]** **[MATH]** **[<PRB>]** **1:rand** **[ENTER]** for the first two lines in screen 1.
4. Press **[MATH]** **[<PRB>]** **5:randInt(1** **[,]** **24** **[,]** **5** **[ENTER]** **[ENTER]** for the next three lines in screen 1.

The randomly generated integers, which all have values between 1 and 24 with possible repeats, are grouped by five because this number is convenient and shows well on the screen.

The first eight integers, after ignoring the repeated 24, are **24, 7, 19, 4, 18, 13, 15, 1**, or in order: **1, 4, 7, 13, 15, 18, 19, 24**. The committee is made up of Bertha, Flora, Marge, Ann, Chris, Cheyenne, Tom, and Mary, thus six females and two males. If these people stood up in an actual classroom, you could see how they are scattered about the room with different heights, weights, and gender (see the asterisks next to the identification numbers in the class table to see some of this variability).

(1) A TI-83 calculator screen showing the following text:
456→rand
randInt(1,24,5
(24 7 19 24 4)
(18 13 15 1 17)

Stratified Sampling

In the previous example, if you want to ensure that the committee is made up in the same proportion of males and females that are in the class, you would need five females and three males ($15/24 = 5/8$ and $9/24 = 3/8$). Do this as follows.

1. Number the female class members F1 to F15 and the male class members M1 to M9 (see the numbers under the names in the class table).
2. Set the seed, and generate random integers from 1 to 15 and from 1 to 9, as shown in screen 2, for the following committee (in order).

Female: F2, F6, F9, F12, F14, or Kay, Bernice, Ann, Cheyenne, and Linda.

Male: M4, M5, M7, or Walter, Frank, and Tom.

(2)

Randomization in Experimental Designs

Randomization is an important component of conducting an experiment. The example that follows tests two teaching methods in our class of 24 students. You will assign the first 12 randomly selected students to Method I with the remainder assigned to Method II.

(3)

1. Set the seed and generate random integers between 1 and 24, as shown in screen 3.

The first 12 values (ignoring repeats of 6 and 20) are **6, 8, 20, 1, 5, 17, 9, 14, 18, 12, 19, and 24**. In order they are **1, 5, 6, 8, 9, 12, 14, 17, 18, 19, 20, 24**.

As a result, Bertha, Kojo, Bernice, Bernie, Jim, Shaine, Frank, Shirley, Cheyenne, Tom, Pete, and Mary are assigned to Method I. The remaining 12 students are assigned to Method II.

Activity 5, Collecting Data (cont.)

Topic 20—Gathering Data with the CBL

The CBL System from Texas Instruments comes with a workbook that has detailed instructions and listings of the programs necessary to do many experiments. Texas Instruments has other manuals with activities for the CBL. *Real-World Math with the CBL System* by Brueningsen et al has activities that could be adopted to hypotheses testing. For example, in Activity 15 of the Brueningsen book, you could hypothesize that the dominant hand can generate more rapid light pulses than the non-dominant hand; or in Activity 22, you could test if one group (for example, basketball players) jumps higher, on average, than another (non-basketball players or football players).

The experiment below is modified from the *CBL SYSTEM Experiment Workbook* and uses the temperature probe that comes with the CBL unit. This experiment was picked because it is easy to set up and conduct.

Newton's Law of Cooling

The rate at which a warm body cools is proportional to the temperature difference between the temperature of the warm object (T) and the temperature of its surroundings (C). Mathematically, this is equivalent to $(T - C) = A * e^{-kt}$, where A is a constant depending on the initial temperature of the object and k is a proportionality constant. (See "Experiment P3" in the *CBL SYSTEM Experiment Workbook*.) This experiment works well with Topic 13 and with model fitting.

A hot cup of coffee cools because the surrounding air is at a lower temperature. The greater the temperature difference, the more rapid the cooling. As the coffee approaches room temperature, it cools very slowly and remains lukewarm for a long period. We say its temperature is lowering at a decreasing rate instead of at the constant rate a straight line would indicate on a plot of temperature versus time. To show the relationship between temperature and time, do the following.

1. Put some boiling water in a Thermos™ for easy and safe transport.
2. Connect the TI-83 to the CBL as if it were another TI-83. Connect the temperature probe to **CH2** on the top edge of the CBL unit.
3. Turn on both the CBL unit and the TI-83.

4. With the temperature probe at room temperature, run the **COOLTEMP** program from the workbook (and listed at the end of this topic).

To avoid conduction and evaporation effects on the temperature probe, do not place the probe directly on the table top or expose it to any drafts.

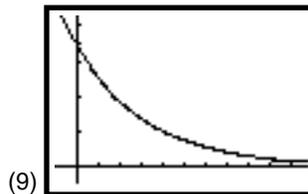
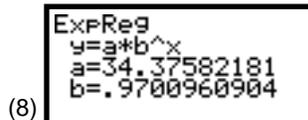
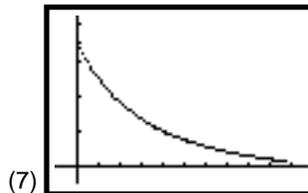
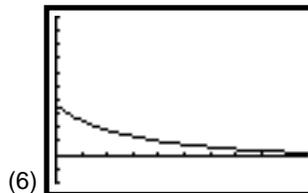
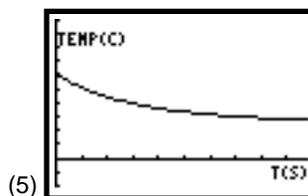
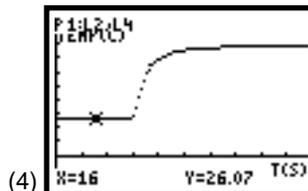
5. After the **COOLTEMP** program has run about 30 seconds, put the probe into the hot water, and watch the temperature rise. (See screen 4.)
6. After the **COOLTEMP** program stops running (about 1.5 minutes), press **TRACE**, and read the room temperature (26.07°C), the **Y** value shown in the bottom of screen 4.
7. Lift the probe from the water, flick off the last drop of water, and run the **COOLTEMP** program for the cooling curve in screen 5. (Again, keep the probe out of drafts, and do not let it touch the table.)

Notice how the probe cooled a bit before you started recording and how the temperature continues to drop, leveling off to the room temperature.

8. Because the rate of change of the temperature is proportional to the difference between the temperature of the liquid and the room temperature, subtract room temperature from each of the liquid readings stored by the program in **L4**. Note that the time, in seconds, is stored in **L2**.

- a. From the home screen, enter **L4** $\boxed{-}$ **26.07** **STO** \rightarrow **L4**.
- b. Press **GRAPH** for screen 6. With the room temperature subtracted, this curve is approaching zero as you might expect.
- c. Press **ZOOM** **9:ZoomStat**, and the data fills up the screen, as shown in screen 7.

9. The line is not straight. Theory predicts exponential cooling, so do as follows.
 - a. Press **STAT** **[CALC]** **0:ExpReg** **L2, L4, Y1** **ENTER**, which gives screen 8 with $y = a * b^x$, where **a = 34.37582181** and **b = 0.9700960904**.
 - b. Press **GRAPH** for screen 9, which shows this curve fitting the data very well.



Note: $34.3758 * 0.9701^x =$
 $34.3758 * e^{(\ln 0.9701 * X)} =$
 $34.3758 * e^{(-0.0304 * X)}$.

Activity 5, Collecting Data (cont.)

Program COOLTEMP.83p

```
PlotsOff
Func
FnOff
AxesOn
0→Xmin
99→Xmax
10→Xsc1
-20→Ymin
100→Ymax
10→Ysc1
ClrList L2 , L4
ClrHome
{1,0}→L1
Send(L1)
{1,2,1}→L1
Send(L1)
99→dim(L4)
ClrHome
Disp "PRESS ENTER TO"
Disp "START GRAPHING"
Disp "TEMPERATURE:"
Pause
ClrDraw
Text(4,1,"TEMP(C)":Text(54,81,"T(S)")
{3,1,-1,0}→L1
Send(L1)
For(I,1,99,1)
Get(L4(I))
Pt-On(I,L4(I))
End
seq(N,N,0,98,1)→L2
0→Xmin
max(L2)→Xmax
10→Xsc1
Plot1(Scatter,L2,L4,·)
DispGraph
Text(4,1,"TEMP(C)":Text(54,81,"T(S)")
Stop
```