# 2007 ITQ ALGEBRA/STATISTICS

# LABORATORY MANUAL

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**Experiment 1**

*Activity #2*
*in Explorations*

# Making Cents of Math

## SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Set the range switch on the force sensor to +/- 10N.
3. Connect the force sensor to CH1 of the CBL2.
4. Turn on the calculator.
5. [APPS]
6. [ALPHA] **D** [▼] **DataMate** [ENTER]
7. When the main screen of DATAMATE appears, press [CLEAR].
8. **1:SETUP**
9. If CH1 contains the force sensor, go to step 10, otherwise press [ENTER], select FORCE, and select the correct force sensor.
10. [▲] **MODE** [ENTER]
11. **3:EVENTS WITH ENTRY**

## DATA COLLECTION

1. Hang the empty cup from the force sensor.
2. **3:ZERO**
3. **1:CH1-FORCE(N)**
4. When the cup stops swinging, press [ENTER] (the weight of the cup is initialized to zero).
5. **2:START** (to begin data collection).
6. [ENTER] (records the weight of 0 pennies); enter **0** for the number of pennies.
7. [ENTER] (records the weight of 8 pennies); enter **8** for the number of pennies.
8. [ENTER] (records the weight of 16 pennies); enter **16** for the number of pennies.
9. [ENTER] (records the weight of 24 pennies); enter **24** for the number of pennies.
10. [ENTER] (records the weight of 32 pennies); enter **32** for the number of pennies.
11. [STO▶] (you are through collecting data).

## TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. ENTER to return to the main screen of DATAMATE.
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case the numbers of pennies are stored in $L_1$ and their weight in $L_2$).
3. ENTER

## INSPECT AND CORRECT THE DATA

1. STAT
2. **1:Edit**

## DATA ANALYSIS - CALCULATION OF THE REGRESSION EQUATION

1. 2nd [CATALOG] **D**
2. ▼ **DiagnosticOn** ENTER (to list $r$ and $r^2$).
3. STAT ► CALC
4. **4:LinReg(ax+b)**
5. 2nd [L1] , 2nd [L2] ,
6. VARS ► Y-VARS
7. **1:Function**
8. **1:Y1** (stores the regression line $y = ax + b$ in $Y_1$).
9. ENTER (lists the regression line $y = ax + b$, $r$, $r^2$).

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

1. 2nd [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: 2nd [L1]
6. Ylist: 2nd [L2]
7. Mark: +
8. ZOOM
9. **9:ZoomStat**

# LAB REPORT

1. Use $L_2$ and the regression equation to fill in the Data Table except for the model equation.
2. For your regression line, determine the percentage of the variation in force ($y$) that is due to its linear relationship with the number ($x$) of cents.
3. Answer questions 1-10 and the two applications.
   Remark 1: in #6 use the first data point and any other data point.
   Remark 2: in #8 use step 6 instead of step 4.
4. Compare the lines obtained in the model equation with the regression line you recorded. (Determine the % relative error for the slope $m$ using the regression line as the actual line and the model line as the predicted line).

$$\% \text{ relative error} = \frac{\text{predicted value} - \text{actual value}}{|\text{actual value}|} \times 100$$

**Experiment 2**

*Activity #18*
*in Explorations*

# Charging Up, Charging Down

## SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Connect the voltage probe to CH1 on the CBL2.
3. Turn on the calculator.
4. [APPS]
5. [ALPHA] **D** [▼] **DataMate** [ENTER]
6. When the main screen of DATAMATE appears, press [CLEAR].
7. **1:SETUP**
8. [▲] **MODE** [ENTER]
9. **2:TIME GRAPH**
10. **2:CHANGE TIME SETTINGS**
11. **0.5** (seconds between samples) and press [ENTER].
12. **100** (number of samples) and press [ENTER].
13. **1:OK** twice.

## DATA COLLECTION

1. Connect the capacitor-resistor circuit as shown on page 176.
2. Connect the red (positive) lead to the positive side of the capacitor and the black lead to the other side.
3. Connect the battery to the circuit, positive-to-positive and negative-to negative.
4. Remove the battery from the circuit and quickly select **2:START** to begin data collection.
5. After data collection is completed, a graph of voltage vs. time will be displayed.

## TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. [ENTER] to return to the main screen of DATAMATE.
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case time is stored in $L_1$ and voltage (CH1) is stored in $L_2$).
3. [ENTER] (the data has been transferred to the calculator).

## INSPECT AND CORRECT THE DATA

1. STAT
2. **1:Edit**

## DATA ANALYSIS - CALCULATION OF THE REGRESSION EQUATION

1. 2nd [CATALOG] **D**
2. ▼ **DiagnosticOn** ENTER (to list $r$ and $r^2$).
3. STAT ▶ CALC
4. **0:ExpReg**
5. 2nd [L1] , 2nd [L2] ,
6. VARS ▶ Y-VARS
7. **1:Function**
8. **1:Y1** (stores the exponential regression curve $y = ab^x$ in $Y_1$).
9. ENTER (lists the exponential regression curve $y = ab^x$, $r$, $r^2$).

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

1. 2nd [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: 2nd [L1]
6. Ylist: 2nd [L2]
7. Mark: ·
8. ZOOM
9. **9:ZoomStat**

# LAB REPORT

1. a. Deactivate $Y_1$ (press [Y=], then take the highlight off the equality sign by pressing [ENTER]).
   b. Redisplay the graph ([ZOOM], **9:ZoomStat**).
   c. Use [TRACE] to move the cursor along the data plot.
   d. Determine the approximate time at which the capacitors voltage reached half its initial value (called the half-life denoted $t_{1/2}$) and record the value in the data table.

   $$t_{1/2} =$$

2. Notice that the exponential regression equation used by the calculator is of the form $y = ab^x$ while the modeling equation used in this activity is $y = Ve^{-Kx}$. Calculate $V$ and $K$ for your regression equation and enter them in the data table.

   $$V =$$

   $$K =$$

3. Use the decay equation $y = Ve^{-Kx}$ to derive the half-life equation $t_{1/2} = \dfrac{\ln 2}{K}$ .

4. How does the half-life computed from the regression equation compare to the one you extracted from the graph? Compute the percent relative error using the half-life obtained from the regression equation as the actual half-life.

   $$\%\text{ relative error} = \frac{\text{predicted value} - \text{actual value}}{|\text{actual value}|} \times 100$$

5. According to the model, when does the capacitor voltage reach exactly zero?

**Experiment 3**

*Activity #3*
*in CBL2 Manual*

# Dualing Sensors

## SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Connect one temperature sensor to CH1 of the CBL2 and the other to CH2.
3. Place the two sensors in the lukewarm water.
4. Turn on the calculator.
5. [APPS]
6. [ALPHA] **D** [▼] **DataMate** [ENTER]
7. When the main screen of DATAMATE appears, press [CLEAR].
8. **1:SETUP**
9. [▼] **CH2** [ENTER]
10. **1:TEMPERATURE**
11. **5:STAINLESS TEMP (F)** (Now CH1 measures temperature in Celsius and CH2 in Fahrenheit).
12. [▼] **MODE** [ENTER]
13. **5:SELECTED EVENTS**
14. **1:OK** (to return to the DATAMATE main screen).

## DATA COLLECTION

1. **2:START**
2. [ENTER] (this is your first data point)
3. Add ice, stir with the sensors, wait 5 or 10 seconds.
4. Repeat steps 2 and 3 until you have collected 10 data points (at the last data point, the Celsius temperature should be close to 0).
5. [STO►] (you are through collecting data).

## TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. **1:MAIN SCREEN** to return to the main screen of DATAMATE.
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case the Celsius temperatures (CH1) are stored in $L_2$ and the Fahrenheit temperatures (CH2) in $L_3$).
3. [ENTER]

## INSPECT AND CORRECT THE DATA

1. [STAT]
2. **1:Edit**

## DATA ANALYSIS - CALCULATION OF THE REGRESSION EQUATION

1. [2nd] [CATALOG] **D**
2. [▼] **DiagnosticOn** [ENTER] (to list $r$ and $r^2$).
3. [STAT] [►] CALC
4. **4:LinReg(ax+b)**
5. [2nd] [L2] [,] [2nd] [L3] [,]
6. [VARS] [►] Y-VARS
7. **1:Function**
8. **1:Y1** (stores the regression line $y = ax + b$ in $Y_1$).
9. [ENTER] (lists the regression line $y = ax + b$, $r$, $r^2$).

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

1. [2nd] [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: [2nd] [L2]
6. Ylist: [2nd] [L3]
7. Mark: +
8. [ZOOM]
9. **9:ZoomStat**

# LAB REPORT

1. Answer questions 1-7 (in #1, just graph the regression line).

2. For your regression line, determine the percentage of the variation in Fahrenheit temperature (F) that is due to its linear relationship with Celsius temperature (C).

3. Compare the line in question #2 on page 54 with the actual line in question #6 on page 55. (Determine the % relative error for $m$ and for $b$.)

$$\% \text{ relative error} = \frac{\text{predicted value} - \text{actual value}}{|\text{actual value}|} \times 100$$

4. Algebraically, determine the actual line $C = MF + B$ from the actual line in question #6 on page 55.

5. Write the calculator commands that would produce the regression line $C = MF + B$.

## Experiment 4

*Activity #19*
*in Explorations*

# Bounce Back

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### SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Connect the motion detector to DIG/SONIC port of the CBL2.
3. Turn on the calculator.
4. [APPS]
5. [ALPHA] **D** [▼] **DataMate** [ENTER]
6. When the main screen of DATAMATE appears, press [CLEAR].

### DATA COLLECTION

1. Hold the motion detector about 1.5 m above the floor pointing downward.
2. Practice dropping the ball from a height so that it bounces directly beneath the motion detector. If the ball moves slightly to the side, move the motion detector horizontally to stay directly above the ball.
3. Select **2:START** to begin data collection. When you hear the data collection device beep, immediately drop the ball under the detector as you practiced. Data collection will run for 5 seconds.
4. [ENTER] to display the DISTANCE graph. The graph should contain a series of at least 5 smoothly changing parabolic regions. Since the motion detector was pointing downward, it measures increasing values away from itself and the graph will appear to be upside down. (To repeat data collection, [ENTER], select **1:MAIN SCREEN**, select **2:START**.)
5. [ENTER] (you are satisfied with the graph)

### TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. **1:MAIN SCREEN**
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case, time is stored in $L_1$ and distance in $L_6$)
3. [ENTER]

## ADJUSTING THE DATA

To make the distance versus time graph a bit easier to work with, you can adjust the coordinate system by subtracting all the distance values from the maximum distance value, which will allow you to re-graph the distance data so that the bounce height will be shown on the $y$-axis. See the figure on the handout. We will store **max(**$L_6$**)**-$L_6$ in $L_4$ so that $L_4$ contains the bounce heights.

1. MATH ▶ NUM
2. **7:max(**
3. 2nd [L6] ) − 2nd [L6]
4. STO▶ 2nd [L4] ENTER

## DATA ANALYSIS - GRAPH OF THE SCATTER PLOT OF THE BOUNCE HEIGHT

1. 2nd [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the second plot type (line graph).
5. Xlist: 2nd [L1]
6. Ylist: 2nd [L4]
7. Mark: +
8. ZOOM
9. **9:ZoomStat**

Use TRACE to obtain the six bounce heights and record them to the nearest 0.001 in DATA TABLE. Store the bounce heights in $L_3$ and store the corresponding number of bounces (0 through 5) in $L_2$.

## DATA ANALYSIS - CALCULATION OF THE REGRESSION EQUATION

1. 2nd [CATALOG] **D**
2. ▼ **DiagnosticOn** ENTER (to list $r$ and $r^2$).
3. STAT ▶ CALC
4. **0:ExpReg**
5. 2nd [L2] , 2nd [L3] ,
6. VARS ▶ Y-VARS
7. **1:Function**
8. **1:Y1** (stores the exponential regression curve $y = ab^x$ in $Y_1$).
9. ENTER (lists the exponential regression curve $y = ab^x$, $r$, $r^2$).

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

1. 2nd [STAT PLOT]
2. **1:Plot1**
3. **Off**
4. 2nd [STAT PLOT]
5. **2:Plot2**
6. **On**
7. Select the first plot type (scatter plot).
8. Xlist: 2nd [L2]
9. Ylist: 2nd [L3]
10. Mark: +
11. ZOOM
12. **9:ZoomStat**

# LAB REPORT

1. Use the function $y = h_0 p^x$ to explain why $h_0$ is equal to the $y$-intercept.

2. Use two distinct heights to estimate the rebound height equation $y = h_0 p^x$.

3. Compare the values of $p$ obtained in the regression equation and the equation in #2. (Determine the % relative error in $p$ using the regression equation as the actual equation.)

4. Use the regression equation to determine the smallest integer number of bounces required by the ball for the rebound height to be less than 10% of its starting height.

## Experiment 5

*Activity #20*
*in Explorations*

# Sour Chemistry

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### SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Connect the pH sensor to CH1 on the CBL2.
3. Turn on the calculator.
4. [APPS]
5. [ALPHA] **D** [▼] **DataMate** [ENTER]
6. When the main screen of DATAMATE appears, press [CLEAR].
7. **1:SETUP**
8. [▲] **MODE** [ENTER]
9. **2:TIME GRAPH**
10. **2:CHANGE TIME SETTINGS**
11. **0.5** (seconds between samples) and press [ENTER].
12. **100** (number of samples) and press [ENTER].
13. **1:OK** twice.

### DATA COLLECTION

1. Place about 125 mL of distilled water in a very clean cup.
2. Loosen the top of the pH storage bottle, and carefully remove the bottle.
3. Rinse the tip of the pH sensor in the water, and support it so that the sensor does not fall.
4. Put 20 drops of lemon juice in the water. This will simulate an acid stomach. Stir gently with the sensor.
5. Drop the effervescent tablet in the water and about 1/2 second later, select **2:START** to begin data collection.
6. Data collection starts after the beep. Data collection will run for 50 seconds.
7. After collection ends, a graph of pH vs. time will be displayed. The graph will show pH values that increase rapidly at first and then level off. If you are not satisfied with the data, rinse the cup and the pH sensor in distilled water and start over.

## TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. ENTER to return to the main screen of DATAMATE.
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case time is stored in $L_1$ and pH (CH1) is stored in $L_2$).
3. ENTER (the data has been transferred to the calculator).
4. Use distilled water to rinse the sensor. Replace the storage bottle on the pH sensor.

## ADJUSTING THE DATA

$y = A(1 - B^x) + C$ or, equivalently, $(A + C) - y = AB^x$ models this data where $C$ represents the initial pH of the solution, i.e., the $y$-intercept, $A$ measures the magnitude of the pH change while $B$ is a value between 0 and 1 which measures the pH rate of change.

Therefore, we can find the maximum pH value $M$ of the data and use $1.0015M$ to estimate the limiting value $L$ of the pH curve as $x$ approaches infinity (this limiting value $L$ should equal $A + C$).

Record the value of $L$ in the DATA TABLE. $\hat{y} = L - y = AB^x$ can then be obtained with exponential regression. First we will calculate $L$ and store the adjusted data values $L - y$ in $L_3$.

1. **1.0015** * MATH ► NUM
2. **7:max(** 2nd [L2] )
3. STO► ALPHA **L** ENTER
4. ALPHA **L** − 2nd [L2]
5. STO► 2nd [L3] ENTER

## DATA ANALYSIS - GRAPH OF THE TRANSFORMED DATA

Plot the transformed data to show that it is indeed exponential (decay).

1. 2nd [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: 2nd [L1]
6. Ylist: 2nd [L3]
7. Mark: +
8. ZOOM
9. **9:ZoomStat**

## DATA ANALYSIS
## CALCULATION OF THE REGRESSION EQUATION OF THE TRANSFORMED DATA

1. [2nd] [CATALOG] **D**
2. [▼] **DiagnosticOn** [ENTER] (to list $r$ and $r^2$).
3. [STAT] [►] CALC
4. **0:ExpReg**
5. [2nd] [L1] [,] [2nd] [L3] [,]
6. [VARS] [►] Y-VARS
7. **1:Function**
8. **1:Y2** (stores the exponential regression curve $y = ab^x$ in $Y_2$).
9. [ENTER] (lists the exponential regression curve $y = ab^x$, $r$, $r^2$).

You might use Plot2 to plot $Y_2$ and the adjusted data to see that you have an exponential fit ($L_1$ versus $L_3$).

To store $a$ in $A$, $b$ in $B$, and the $y$-intercept $L - a$ in $C$:

1. [VARS]
2. **5:Statistics**
3. [►] [►] EQ
4. **2:a**
5. [STO►] [ALPHA] **A**
6. [ENTER]
7. [VARS]
8. **5:Statistics**
9. [►] [►] EQ
10. **3:b**
11. [STO►] [ALPHA] **B**
12. [ENTER]
13. [ALPHA] **L** [−] [ALPHA] **A**
14. [STO►] [ALPHA] **C**
15. [ENTER]

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

Your model is $y = A(1 - B^x) + C$. Store this model in $Y_1$. Be sure to highlight $Y_1$ and deactivate $Y_2$. Last, plot $Y_1$ and the original scatterplot in Plot1. (Plot1 gives the original data and the logistic function $y = A(1 - B^x) + C$.)

1. (2nd) [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: (2nd) [L1]
6. Ylist: (2nd) [L2]
7. Mark: +
8. (ZOOM)
9. **9:ZoomStat**

Note: You can also model the data with logistic regression ((STAT)(►) CALC, **B:Logistic**).

# LAB REPORT

1. Show that the model equation $y = A(1 - B^x) + C$ is equivalent to $(A + C) - y = AB^x$.

2. Show that $C$ is the $y$-intercept of the function of the model equation.

3. Explain why the right hand side of the model equation approaches the sum $A + C$ as $x$ approaches infinity.

**Experiment 6**

*Activity #16*
*in Explorations*

# Light at a Distance

## SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Connect one light sensor to CH1 of the CBL2.
3. Turn on the calculator.
4. [APPS]
5. [ALPHA] **D** [▼] **DataMate** [ENTER]
6. When the main screen of DATAMATE appears, press [CLEAR].
7. Remove any reflective surfaces that are behind, beside, or below the bulb and any surfaces near the bulb. The filament and the light sensor should be at the same vertical height. While you are taking intensity readings, the light sensor must be pointing directly at the side of the light bulb.
8. **1:SETUP**
9. [▲] **MODE** [ENTER]
10. **3:EVENTS WITH ENTRY** (to collect light intensity data as a function of distance).
11. **1:OK** (to return to the DATAMATE main screen)

## DATA COLLECTION

1. Dim the light to darken the room. A very dark room is critical to obtain good results.
2. Hold the light sensor about 12 inches from the light bulb filament. The yardstick should be directly below the center of the bulb.
3. Move the sensor away from the bulb and observe the displayed intensity values on the calculator screen.
4. Place the light sensor at a starting distance $x_L = 15$ inches from the filament. Make sure that the first intensity reading is less than 1. Record the value of $x_L$ in the DATA TABLE.
5. **2:START**
6. Wait until the intensity value displayed on the calculator stabilizes. Press [ENTER], and then enter the distance (in inches) between the light sensor and the filament. Press [ENTER] to conclude the entry.
7. Move the light sensor 2 inches further away from the bulb and repeat the previous step.

8. Continue moving the sensor in 2-inch increments, collecting data as before, until you have 10 or 11 readings.
9. [STO▶] (you are through collecting data).

## TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. [ENTER] to return to the main screen of DATAMATE.
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case the distances are stored in $L_1$ and the light intensities are stored in $L_2$).
3. [ENTER]

## ADJUST THE DATA

Change the distances from inches to meters. Divide the entries of $L_1$ by 39.37 and store in $L_1$.

1. [2nd] [L1] [÷] **39.37**
2. [STO▶] [2nd] [L1] [ENTER]

## DATA ANALYSIS - CALCULATION OF THE REGRESSION EQUATION

We use power regression to fit the data with a curve $y = ax^b$.

1. [2nd] [CATALOG] **D**
2. [▼] **DiagnosticOn** [ENTER] (to list $r$ and $r^2$).
3. [STAT] [▶] CALC
4. **A:PwrReg**
5. [2nd] [L1] [,] [2nd] [L2] [,]
6. [VARS] [▶] Y-VARS
7. **1:Function**
8. **1:Y1** (stores the power regression curve $y = ax^b$ in $Y_1$).
9. [ENTER] (lists the regression line $y = ax^b$, $r$, $r^2$).

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

1. (2nd) [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: (2nd) [L1]
6. Ylist: (2nd) [L2]
7. Mark: +
8. (ZOOM)
9. **9:ZoomStat**

# LAB REPORT

1. Compare your regression model to the actual model $y = \dfrac{C}{x^2}$ by computing the percent relative error in the exponent.

2. Use TRACE to find the left most data point $(x_L, y_L)$ and the right most data point $(x_R, y_R)$. Then find the power function $y = ax^b$ that passes through these two points algebraically.

## Experiment 7

*Activity #26*
*in Explorations*

# Stay Tuned

### SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Connect one Vernier microphone CH1 of the CBL2.
3. Turn on the calculator. Make sure that it is in radian mode.
4. [APPS]
5. [ALPHA] **D** [▼] **DataMate** [ENTER]
6. When the main screen of DATAMATE appears, press [CLEAR].
7. **1:SETUP**
8. **3:ZERO**
9. **2:ALL CHANNELS**
10. With the room quiet, press [ENTER] (this centers the waveform on zero).

### DATA COLLECTION

1. Strike the tuning fork against a soft object.
2. Produce a sound with the tuning fork, hold it close to the microphone, and select **2:START** to collect data. Data collection begins after the collection devise beeps.
3. After data collection ends, a (sine) graph appears.

### TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. [ENTER] to return to the main screen of DATAMATE.
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case time is stored in $L_1$ and amplitude is stored in $L_2$).
3. [ENTER]

### INSPECT AND CORRECT THE DATA

1. [STAT]
2. **1:Edit**

## DATA ANALYSIS - CALCULATION OF THE REGRESSION EQUATION

1. [2nd] [CATALOG] **D**
2. [▼] **DiagnosticOn** [ENTER] (to list $r$ and $r^2$).
3. [STAT] [►] CALC
4. **C:SinReg**
5. [2nd] [L1] [,] [2nd] [L2] [,]
6. [VARS] [►] Y-VARS
7. **1:Function**
8. **1:Y1** (stores the regression line $y = A\sin(Bx + C)$ in $\mathsf{Y}_1$).
9. [ENTER] (lists the regression line $y = A\sin(Bx + C)$, $r$, $r^2$).

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

1. [2nd] [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: [2nd] [L1]
6. Ylist: [2nd] [L2]
7. Mark: +
8. [ZOOM]
9. **9:ZoomStat**

# LAB REPORT

Fill in the data table and answer questions 1-4 on pages 260 and 261.

**Experiment 8**

*Activity #1*
*in CBL2 Manual*

# Add Them Up!

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## SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Connect the voltage sensor to CH1 of the CBL2.
3. Turn on the calculator.
4. [APPS]
5. [ALPHA] **D** [▼] **DataMate** [ENTER]
6. When the main screen of DATAMATE appears, press [CLEAR].
7. **1:SETUP**
8. [▲] **MODE** [ENTER]
9. **3:EVENTS WITH ENTRY**
10. **1:OK**

## DATA COLLECTION

1. Place the five batteries on the ruler with a half inch separation between each battery.
2. Use your CBL2 and calculator to measure the voltage of each battery. Touch and hold the appropriate voltage leads to the appropriate terminal, red to (+) and black to (–).
3. Record the voltage of each battery on the Student Data Reporting Sheet, question 1.
4. **2:START** (to begin data collection of the batteries in series).
5. [ENTER] (take the voltage of the first battery). After ENTER VALUE?, enter **1** for the number of batteries. Press [ENTER].
6. Place the second battery on the ruler in series with the first.
7. [ENTER] (take the voltage of the first two batteries). After ENTER VALUE?, enter **2** for the number of batteries. Press [ENTER].
8. Repeat steps #6 and #7 until you have the voltage of 3, 4, and 5 batteries in series.
9. [STO►] (you are through collecting data).

## TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. ENTER to return to the main screen of DATAMATE.
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case the numbers of batteries in $L_1$ and their voltage in $L_2$).
3. ENTER

## INSPECT AND CORRECT THE DATA

1. STAT
2. **1:Edit**

## DATA ANALYSIS - CALCULATION OF THE REGRESSION EQUATION

1. 2nd [CATALOG] **D**
2. ▼ **DiagnosticOn** ENTER (to list $r$ and $r^2$).
3. STAT ► CALC
4. **4:LinReg(ax+b)**
5. 2nd [L1] , 2nd [L2] ,
6. VARS ► Y-VARS
7. **1:Function**
8. **1:Y1** (stores the regression line $y = ax + b$ in $Y_1$).
9. ENTER (lists the regression line $y = ax + b$, $r$, $r^2$).

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

1. 2nd [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: 2nd [L1]
6. Ylist: 2nd [L2]
7. Mark: +
8. ZOOM
9. **9:ZoomStat**

# LAB REPORT

1. Do the LAB Report in the CBL2 Manual.

## Experiment 9

*Activity #17*
*in Explorations*

# Chill Out

When you have a hot (cold) drink, you know that it gradually cools off (heats up). Newton's law of cooling (heating) provides us with a model for cooling (heating). It states that the temperature difference $T_{\text{diff}}$ between a hot (cold) object and its surrounding medium decreases exponentially with time.

$$T_{\text{diff}} = T_I e^{-kt}$$

In the model $T_I$ is the initial temperature difference, and $k$ is a positive constant.

### SETUP

1. Connect the CBL2 to the calculator with the unit-to-unit cable.
2. Connect the temperature probe to CH1 on the CBL2.
3. Turn on the calculator.
4. [APPS]
5. [ALPHA] **D** [▼] **DataMate** [ENTER]
6. When the main screen of DATAMATE appears, press [CLEAR].
7. **1:SETUP**
8. [▲] **MODE** [ENTER]
9. **2:TIME GRAPH**
10. **2:CHANGE TIME SETTINGS**
11. **1** (seconds between samples) and press [ENTER].
12. **180** (number of samples) and press [ENTER].
13. **1:OK** twice.

### DATA COLLECTION

1. Obtain a cup of hot water at 45 to 55 $°C$. Place the temperature probe in the water, and wait about 20 seconds for the probe to reach the temperature of the water. Rather than waiting for the water to cool, just remove the temperature probe from the water and observe the cooling of the probe itself. Remove the probe form the water and rest it on the edge of a table. Do not let anything touch the tip of the probe.
2. Select **2:START** from the main screen. Data collection will run for three minutes, after which a graph of temperature versus time will display.

## TRANSFER DATA FROM THE CBL2 TO THE CALCULATOR

1. ENTER to return to the main screen of DATAMATE.
2. **6:QUIT** to leave DATAMATE (the screen provides the location of the data in the calculator; in this case time is stored in $L_1$ and temperature (CH1) is stored in $L_2$).
3. ENTER (the data has been transferred to the calculator).

## ADJUSTING THE DATA

Since the model for Newton's law of cooling uses the difference between the temperature of the warm object and its surroundings, subtract the temperature of the medium from the measured temperature before comparing data to the model. To obtain an estimate for the temperature of the medium, we take the minimum temperature and round it <u>down</u> the nearest tenth.

1. MATH ▶ NUM
2. **6:min(**
3. 2nd [L2] ) ENTER
4. Round the number in step 3 down to the nearest tenth. Store the result in ALPHA **M**.
5. 2nd [L2] − ALPHA **M**
6. STO▶ 2nd [L3] ENTER

## DATA ANALYSIS - CALCULATION OF THE REGRESSION EQUATION

1. 2nd [CATALOG] **D**
2. ▼ **DiagnosticOn** ENTER (to list $r$ and $r^2$).
3. STAT ▶ CALC
4. **0:ExpReg**
5. 2nd [L1] , 2nd [L3] ,
6. VARS ▶ Y-VARS
7. **1:Function**
8. **1:Y1** (stores the exponential regression curve $y = ab^x$ in $Y_1$).
9. ENTER (lists the exponential regression curve $y = ab^x$, $r$, $r^2$).
10. Record the values of $a$ and $b$ to three significant digits in your regression equation in the Data Table.

## DATA ANALYSIS
## GRAPH OF THE SCATTER PLOT AND THE REGRESSION EQUATION

1. (2nd) [STAT PLOT]
2. **1:Plot1**
3. **On**
4. Select the first plot type (scatter plot).
5. Xlist: (2nd) [L1]
6. Ylist: (2nd) [L3]
7. Mark: ·
8. (ZOOM)
9. **9:ZoomStat**

# LAB REPORT

1. Convert the regression $y = ab^x$ to the form $y = Te^{-kt}$, and record the values of $T$ and $k$ in the Data Table.

2. Answer questions 1., 5., 6., and 8. in the Data Collection and Analysis sheet.