

Introduction to the Practical Use of the CBL and CBR in Physics

Mag. Heinz-Dieter Hinkelmann, Bundeshandelsakademie Wiener Neustadt,
Austria

E-Mail: heinz-dieter.hinkelmann@telecom.at

CBL and CBR from Texas Instruments

CBL™ (Calculator Based Laboratory™) and the Sensors

The *Calculator Based Laboratory (CBL)* was developed by *Texas Instruments Incorporated* for math and science classes. It is a portable, handheld, battery-operated, data collection device for collecting “real world” data. The CBL connects to a TI graphing calculator (the *TI-92*, or the *TI-82*, *TI-83*, *TI-85*, *TI-86*). The data collected with the CBL can be retrieved by one of the graphics calculators for further analysis.



A wide variety of probes, or sensors, such as the Motion Detector, Student Force Sensor, Microphone, Accelerometers, pH System, Dissolve Oxygen Probe, and Barometer, can then be connected to the CBL interface.

Data collection with the CBL is controlled by programs on the calculator. Since the CBL is battery powered, you can take it out of the classroom for experiments such as measuring accelerations, or monitoring the temperature, dissolved oxygen, and pH of a lake or stream. Within the classroom, you can use the CBL as a low-cost alternative to computers for collecting and analysing data.

The CBL unit is an “intelligent” device with its own microprocessor and memory for collecting data and temporarily storing collected data. The CBL can be used to collect data as a stand-alone device and display the results on its built-in LCD display. But its real power is apparent when it is used interactively with one of the TI graphing calculators.

Probes are connected to the CBL unit through input or output channels. There are six channels: three analog channels (CH1, CH2, and CH3), one ultrasonic motion detector channel (SONIC), one digital input channel (DIG IN), and one digital output channel (DIG OUT).

You can collect data at rates up to 10,000 points per second for up to 512 points per channel. Additionally, you can collect data on up to five channels simultaneously. Collected data in real-time you can plot on a calculator at a rate of up to 14 points per second.

The CBL package includes the *CBL Interface*, the “*CBL System Guidebook*”, the “*CBL System Experiment Workbook*” (classroom experiments for math, physics and chemistry), and a carrying case.

There are also three probes to get you started with the CBL:

- *Temperatur Probe*: The probe uses a thermistor to measure temperature between -20° and $+125^{\circ}$ C.
- *Light Probe*: This probe uses a phototransistor to measure light intensity between $10 \mu\text{W}/\text{cm}^2$ and $1 \text{ mW}/\text{cm}^2$.
- *Voltage Probe*: This is a generic probe that you can use to measure voltage between $\pm 10 \text{ V}$ (Channels 1 and 2 only).

The CBL unit has a feature called AutoIDENT. It allows the CBL unit to automatically identify specific probes when you connect them to the channels. It detects the probe and turns on the indicator for that channel in the CBL display. It determines what kind of data is going to be measured and loads an equation for converting the data into the appropriate measurement unit.

Additional sensors and probes can be purchased from *Vernier Software*.

Ultrasonic Motion Detector (0,4 - 0,6 m), *Mikrophone*, *Student Force Sensor* (0,05 - 10 N), *Dual-Range Force Sensor* ($\pm 5 \text{ N}$ and $\pm 50 \text{ N}$), *Low-g Accelerometer* ($\pm 50 \frac{\text{m}}{\text{s}^2}$), *3-Axes Accelerometer* (really three low-g accelerometers mounted at right angles and all placed in a small box), *25-g Accelerometer* ($\pm 250 \frac{\text{m}}{\text{s}^2}$), *Vernier Photogate*, *Magnetic Field Sensor* ($\pm 3,2 \cdot 10^{-4} \text{ T}$ und $\pm 6,4 \cdot 10^{-3} \text{ T}$), *Current & Voltage Probe System* ($\pm 0,6 \text{ A}$, $\pm 6 \text{ V}$), *Pressure Sensor* (0 bis 7 bar), *Biology Gas Pressure Sensor* (between 0,76 and 1,56 bar), *Barometer* (between 0,81 and 1,06 bar), *Direct-Connect Temperature Probe* (between -15° and 110°C), *Standard Temperature Probe System* (between -50°C and 150°C), *Extra Long Temperature Probe System*, *Thermocouple* (between -200° and 1400°C), *pH-System* (0 - 14), *Colorimeter*, *CO₂ Gas Sensor* (0 - 5000 ppm), *Relative Humidity Sensor* (between 0% and 95%), *Dissolved Oxygen Probe* (between 0 and 15 mg/l), *Heart Rate Monitor*, *Exercise Heart Rate Monitor*, *EKG Sensor*, *Conductivity Probe*, *Student Radiation Monitor*.

The CBR™ (Computer Based Ranger™)

With the CBR and a TI graphing calculator you can collect, view, and analyse motion data (distance, velocity, acceleration). The CBR works like the motion detector of the CBL that connects directly to the TI graphing calculator. No CBL is required. The CBR can also be used as a conventional motion detector with the CBL. But you cannot connect CBR to CBL at the same time that CBR is connected to a calculator.

The CBR includes the RANGER program. The known programs MATCH and BOUNCING BALL are built into RANGER. It is easy to transfer the appropriate program from the CBR. You connect CBR to a TI graphing calculator using the

calculator-to-CBR cable. Next, open the pivoting head on the CBR, and then press the appropriate program-transfer button on the CBR (e.g. 92). When the transfer is complete, the green light on CBR flashes once, CBR beeps once. Now the program is in the memory of the calculator and you can run it. The sonic sensor records up to 200 samples per second with a range between 0.5 meters and 6 meters.

CBR measures the time interval between transmitting the ultrasonic pulse and the first returned echo. When the data is collected, the built-in microprocessor calculates the distance of the object from the CBR using a speed-of-sound calculation. Then it computes the first and second derivatives of the distance data with respect to time to obtain velocity and acceleration data. It stores this measurements in lists L1 (time), L2 (distance), L3 (velocity), and L4 (acceleration).

The Experiments

Using the sensors or probes with the CBL system you have to do the following:

- Connect the CBL unit to the TI graphing calculator using the I/O ports located on each unit. Be sure to push both plugs in firmly.
- If it is necessary, use an adapter to connect the sensor or probe to any of the analog input ports (CH1, CH2, or CH3). In most cases, CH1 is used.
- Run a program to monitor the signal from the sensor or probe. It should be a program developed specifically for use with the sensor. There are programs from *Vernier* and *Texas Instruments*. The programs are available on the Internet. You can download the files from the web sites:

www.vernier.com or www.ti.com

If you have the TI-GRAPH-LINK™ software and cable, you can load the program from an IBM-compatible or Macintosh computer.

The CBR includes, how described, its RANGER program.

The TI View Screens™ make it possible to enlarge and project the image of the calculator display so that it can be viewed by an entire class. These LCD projection panels are valuable instructional aids as you teach students.

Station 1: The CBL and the Basic Equipment

1. Discharging of a capacitor

When a capacitor discharges, its voltage follows an exponential phenomenon:

$U(t) = U_0 \cdot e^{-kt}$ ($U(t)$... voltage across the capacitor at any time, U_0 ... capacitor's initial voltage, k ... constant that depends on the physical characteristics of the capacitor, t ... time, e ... base of the natural logarithm)

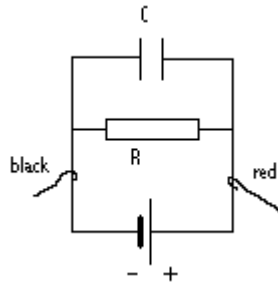
Equipment required:

- CBL Unit, TI-92 Calculator with Unit to Unit Link Cable
- TI Voltage Probe
- Capacitor (220 μF), Resistor (100 $\text{k}\Omega$), Battery (9 V)

Program for measurement:

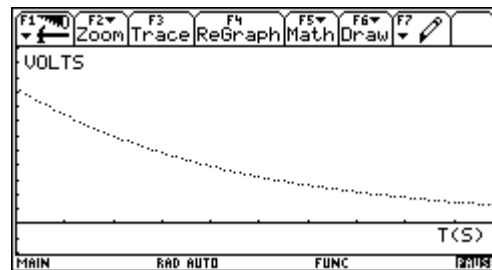
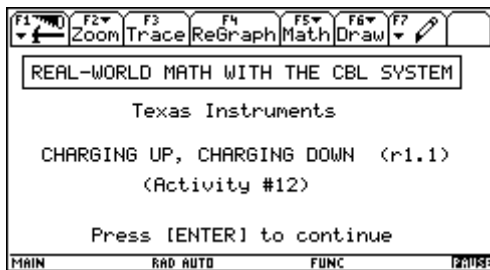
- CHARGE.92p (Texas Instruments)

Instructions:

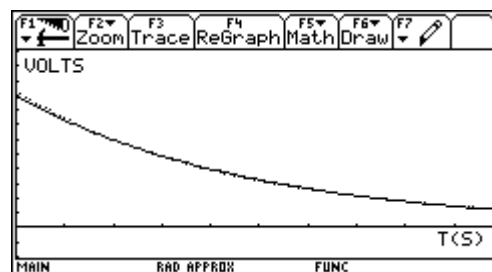


We start the CHARGE program on the TI-92 calculator and follow the directions on the screen to complete the activity.

The data plot should show voltage that decrease rapidly at first, then level off.



The CBL system will store time values (in seconds) in list L1 and voltage values (in volts) in list L2. Therefore we can perform an exponential regression. The results can look like the following:



2. Intensity of Light

Intensity of light is defined as the rate at which energy is transferred per unit area, measured in watts per square meter. As light propagates away from its source, the energy associated with it tends to spread out. The intensity of light decreases as the distance from the source increases. This relationship is expressed in an inverse square law:

$$I = \frac{c}{r^2}$$

(I ... intensity, c ... constant that depends on the physical characteristics of the light source, r ... distance)

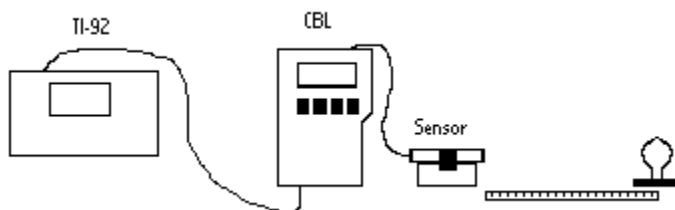
Equipment required:

- CBL Unit, TI-92 Calculator with Unit to Unit Link Cable
- TI Light Probe
- Light Bulb (25 W)
- Wooden Block, Tape
- Meter Stick

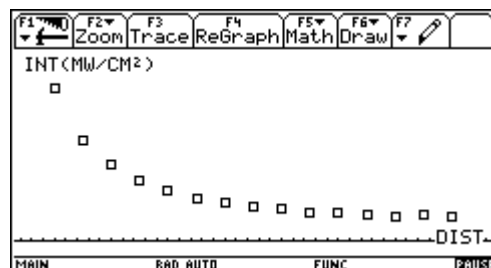
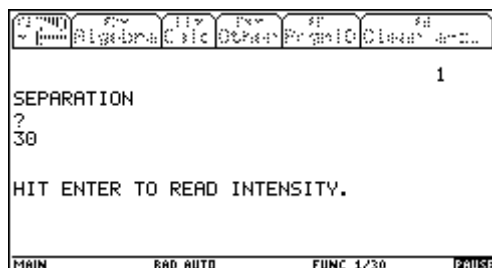
Program for measurement:

- LIGHT.92p (*Texas Instruments*)

Instructions:



We secure the light probe to a wooden block using a tape. The structure of the experiment is shown in the setup diagram. We start the LIGHT program on TI-92 calculator and select “2:SEPARATION” from the LIGHT menu. We enter 15 when prompted for the number of data points to be collected. The first separation between the light probe and the center of the bulb will be 30 cm. We enter 30 when prompted for the separation and press <Enter> to collect the corresponding light intensity. Then we move the probe 35 cm from the bulb and enter 35 when prompted for the separation. We press <Enter> to record the corresponding intensity. We continue in this fashion until 15 data points have been collected. After the data has been collected, a plot of light intensity (in mW/cm²) versus separation (in centimeters) will appear on the display.



The CBL system will store intensity values (in mW/cm²) in list L4, and corresponding separations (in cm) in list L2. Therefore we can perform a power regression. The results can look like the following:

DATA	Abst.	Int.	c3	c4	c5
1	30	.0739			
2	35	.04905			
3	40	.03718			
4	45	.02939			
5	50	.02383			
6	55	.02049			
7	60	.01826			

r1c3=

MAIN RAD AUTO FUNC

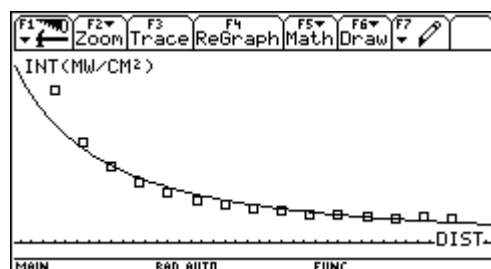
DATA	Abst.	Int.	c3	c4	c5
1	30	.0739			
2	35	.04905			
3	40	.03718			
4	45	.02939			
5	50	.02383			
6	55	.02049			
7	60	.01826			

y=a·x^b
a = 8.987195
b = -1.485071

Enter=OK

c3.Title=

MAIN RAD AUTO FUNC



3. Newton's Law of Cooling

Newton stated that the rate at which a warm body cools is approximately proportional to the temperature difference between the temperature of the warm object and the temperature of its surroundings. Stated mathematically:

$$T - C = (T - T_0) e^{-kt}$$

(T ... body's temperature at some instant, C ... surrounding temperature, T₀ ... body's temperature when t = 0, t ... time)

In this exercise we attempt to verify the mathematical model developed by Newton.

Equipment required:

- CBL Unit, TI-92 Calculator with Unit to Unit Link Cable
- TI Temperature Probe

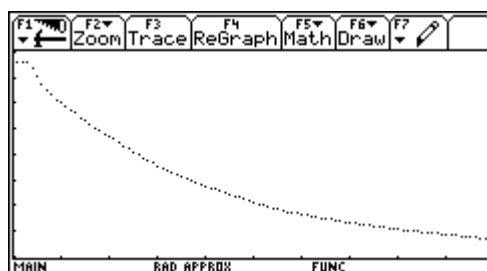
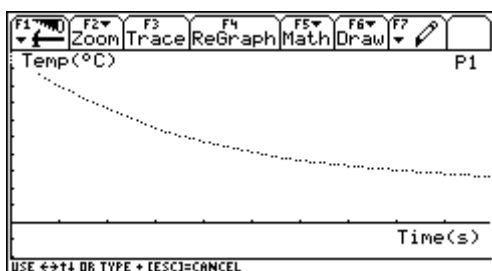
- Hot plate
- Medium beaker and water

Program for measurement:

- CBL.92p (*Texas Instruments*)
- TEMP.92p (*Texas Instruments*)

Instructions:

We connect the temperature probe to the CH1 input and start the CBL program on the TI-92 and select “2:TEMPERATURE” from the CBL MAIN menu. We select AUTO SCALE from the WINDOW OPTIONS menu and enter one second when prompted for the data collection time interval. We place the temperature probe in the beaker of boiling water for several seconds. We remove the probe from the boiling water and press <Enter> to start collecting data. Now we can observe variations in temperature on the display as the data is being collected. After the CBL has finished collecting data, we may want to adjust in “<♦> WINDOW” to create an appropriate viewing window.



Station 2: The CBL and the Microphone

When a tuning fork vibrates, it disturbs nearby air molecules, creating compressions and rarefactions. It is possible to digitize these pressure variations using a microphone. The resulting signal can then be transferred to a graphics calculator and displayed on its screen in the form of a sinusoidal curve:

$$y = a \cdot \sin(2\pi f \cdot t - \delta)$$

(y ... elongation, a ... amplitude, f ... frequency, t ... time, δ ... angle of phase difference)

When two tones of slightly different frequencies are sounded simultaneously, the loudness of the resulting sound wave fluctuates periodically. This phenomenon is called beats. The frequencies of the two tuning forks must differ by less than 20 Hz..

In these activities we will analyse the tone of a tuning fork, investigate a beat pattern produced using a pair of tuning forks and measure the velocity of sound.

Equipment required:

- CBL Unit, TI-92 Calculator with Unit to Unit Link Cable
- Vernier CBL Microphone

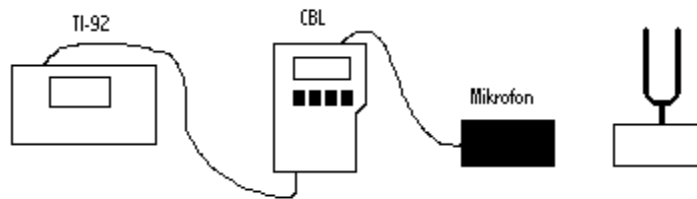
- A Pair of Tuning Forks
- Tube of Cardboard

Program for measurement:

- PHYSICS.92p (*Vernier*)
- BEATS.92p (*Texas Instruments*)

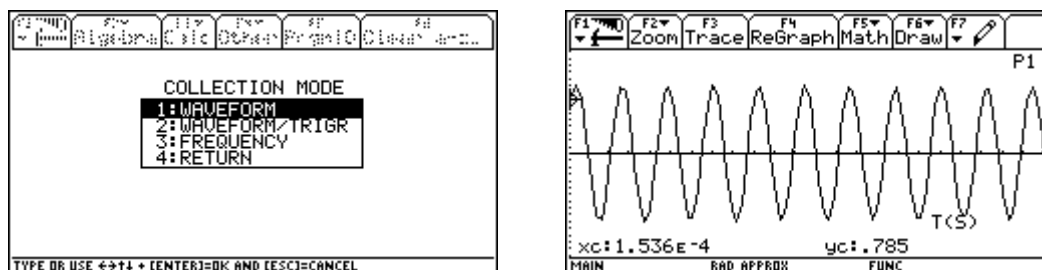
1. Sound Plot

Instructions:



We run the PHYSICS program on our TI-92 and select “1:SET UP PROBES” from the MAIN menu and “4:MICROPHONE” from the following SELECT PROBE menu. We connect the CBL microphone to the CH1 input.

We select “1:WAVEFORM” from the COLLECTION MODE menu, strike the tuning fork, and then we bring the center of the vibrating prong region near the microphone. We press <Enter> to record sound. The resulting pressure-versus-time plot should appear sinusoidal.

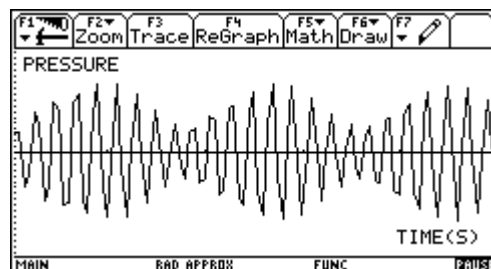
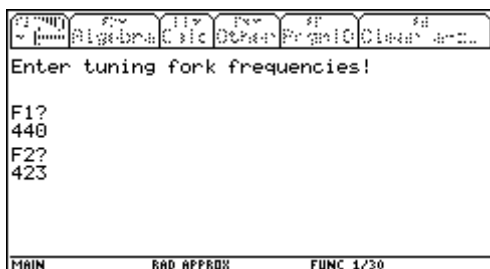


The trace-mode allows us to find the period, T , determine the time required for several complete oscillations. For the used tuning fork: $T = 0.00324 - 0.00102 = 0.00222$ s. The frequency is $1 / 0.00222 = 450$ Hz (the exact frequency is 440 Hz).

2. Beats

The COLLECTION MODE menu allows to determine the frequencies of a pair of tuning forks. Here are the frequencies 440 Hz and 423 Hz.

We start the BEATS program. When prompted by the program, we enter the tuning forks frequencies. This allows the program to select an appropriate data collection rate and viewing window. We strike the tuning forks and press <Enter> to collect the sound data. The resulting pressure-versus-time plot shows the beats.

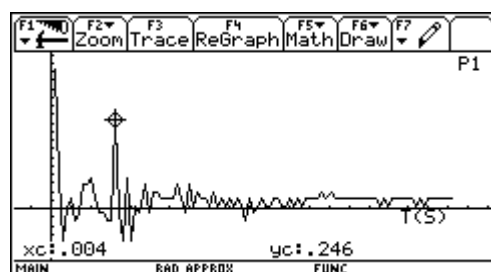
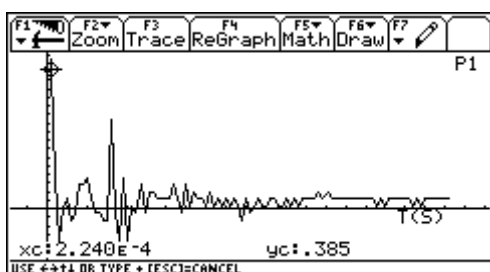


3. Calculation of the Speed of Sound

We run the PHYSICS program and select “2:WAVEFORM/TRIGR” from the COLLECTION MODE menu.

The microphone waits for a certain sound intensity before starting data collection. This allows us to capture a short burst of sound. In this experiment the microphone is held near the open end of a tube. With triggering used, we snap our fingers near the microphone. This triggers data collection. The graph shows the sound of the finger snap plus its reflection from the end of the tube. By measuring the time from the graph and the length of the tube, we can calculate the speed of the sound.

The way of the sound was $2 * 0.645 \text{ m} = 1.29 \text{ m}$, the running time 0.00375 s . The calculation of the speed of sound is $1.29 \text{ m} / 0.00375 \text{ s} = 344 \text{ m/s}$.



Station 3: The CBL and the Student Force Sensor

1. Friction

Friction is a resisting force that acts between two contacting surfaces when one object slides or attempts to slide over the other. Frictional forces depend on the types of surfaces in contact and the normal forces between these surfaces. There are two types of friction - static friction and kinetic friction. Static friction occurs when two surfaces are at rest with respect to each other but one is trying to slide over the other. The force of static friction, F_s , can vary from zero to a maximum value that occurs just before the object slips. Kinetic

friction, F_k , occurs when two surfaces are actually moving with respect to each other. Stated mathematically: $F_s \leq \mu_s N$ (N ... normal force, μ_s ... coefficient of static friction), $F_k = \mu_k N$ (μ_k ... coefficient of kinetic friction).

In this experiment, the nature of the frictional forces between a variety of surface will be investigated. It will be shown in one example only.

Equipment required:

- CBL Unit, TI-92 Calculator with Unit to Unit Link Cable
- Vernier Student Force Sensor with CBL DIN Adapter
- Rectangular wooden block and brick
- String

Program for measurement:

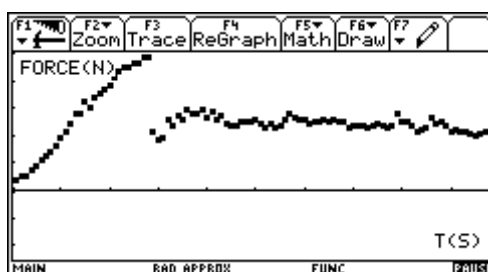
- CBL.92P (*Texas Instruments*)
- FORCERT.92P (*Texas Instruments*)

Instructions:



We connect the force probe to CH1, attach it to the wooden block using a piece of string, and run the CBL program. We select "4: FORCE" from the CBL MAIN menu, and "2:FORCE(RLTIME)" from the FORCE menu. We begin pulling on the block, increasing the applied force at a slow and steady rate. The graph of force-versus-time is plotted on

the display as the data is collected.



2. Harmonic Motion with an Student Force Sensor

Periodic motion is motion that repeats itself over and over again. A mass oscillating on a spring is moving in simple harmonic motion. The position of an oscillating mass at any point in time will be a cosine- (sine-) curve:

$$y = r \cdot \cos(\omega t + \delta)$$

(y ... elongation, r ... amplitude, ω ... angular frequency, t ... time, δ ... angle of phase difference)

There is a force on an oscillating mass:

$$F = -k \cdot y \text{ (Hooke's law)}$$

(F ... force of spring, k ... constant that depends on the physical characteristics of the spring, y ... elongation)

It follows:

$$F = -k \cdot r \cdot \cos(\omega t + \delta)$$

In this exercise, we will examine a graphical display of the motion of a mass hanging from the spring using the student force sensor.

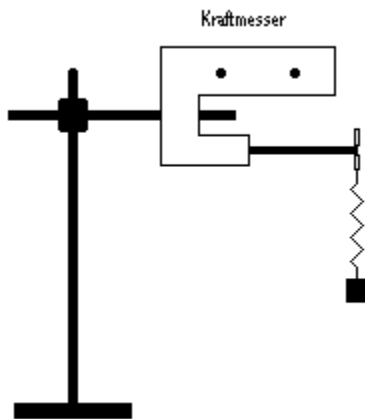
Equipment required:

- CBL Unit, TI-92 Calculator with Unit to Unit Link Cable
- Vernier Student Force Sensor with CBL DIN Adapter
- Spring
- Hanging Mass
- Ring Stand
- Support Rod

Program for measurement:

- CBL.92p (*Texas Instruments*)
- FORCE.92p (*Texas Instruments*)
- PLOTS.92p (*Texas Instruments*)

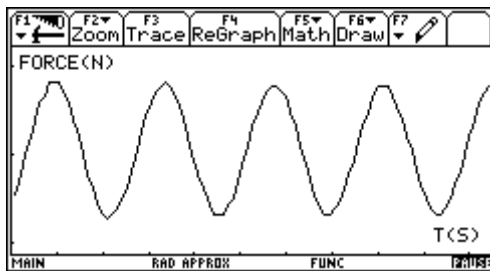
Instructions:



We connect the student force sensor to the CH1 of the CBL using the CBL DIN adapter. We run the CBL program. We select "4: FORCE" from the CBL MAIN menu, and follow the instruction on the screen. It follows the calibration of the sensor and the prompting for the collection time (5 s).

We connect the spring with the force sensor, and we pull the mass straight down about 20 cm and let it go. After the CBL has finished collecting data, we select the suitable choices from the PLOT OPTIONS menu.

The display shows a force-versus-time plot. The TI-92 store force values (in N) to list L4 and corresponding times (in s) to list L2.



	F1	F2	F3	F4	F5	F6	F7
	Plot	Setup	Cell	Header	Calc	Util	Stat
DATA	12=t	14=F					
	c1	c2	c3	c4	c5		
1	.05262	2.5528					
2	.10525	2.7723					
3	.15789	2.9917					
4	.21052	3.2111					
5	.26316	3.3757					
6	.31579	3.5951					
7	.36842	3.6499					
	r1c3=						
	MAIN	RAD APPROX	FUNC				

Station 4: Experiments with the CBR (or CBL and the Ultrasonic Motion Detector)

1. Match it

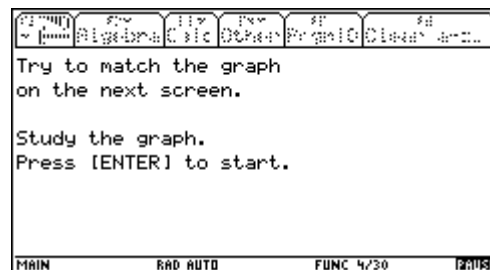
Equipment required:

- CBR Unit, TI-92 Calculator with Unit to Unit Link Cable
- Meter Stick
- Masking Tape

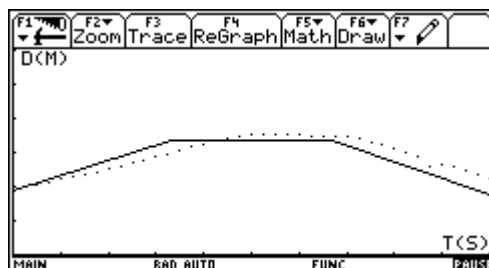
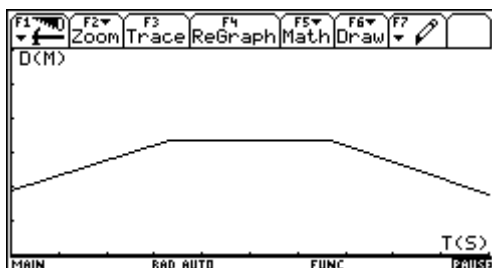
Instructions:

By moving in a specific way in front of the CBR, we can attempt to make a motion plot that matches a given distance-time or velocity-time plot. We can change the shape of the plot by adjusting the starting position, speed, and the direction in which we move.

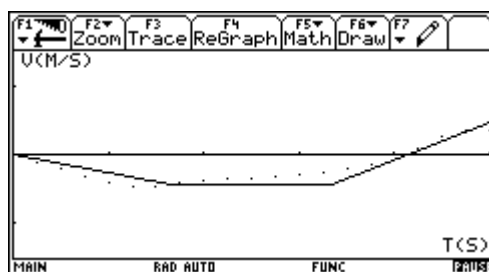
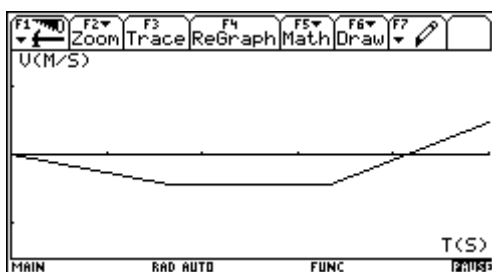
We run the RANGER program on our calculator, choose “3:Applications” from the MAIN menu and “2:Meters”. Then we select “1:Distance Match” from the APPLICATIONS menu, and follow the directions on the calculator screen.



We use meter stick and masking tape on the floor to help gauge our distance from the CBR. If we are not happy with the result, we can try again. A typical result may be the following:



More difficult is it to match a velocity-time graph (choosing “2:Velocity Match” from the APPLICATIONS menu), but the proceedings are the same:



2. Harmonic Motion

A mass oscillating on a spring is moving in simple harmonic motion. The position of an oscillating mass at any point in time will be a cosine- (sine-) curve:

$$y = r \cdot \cos(\omega t + \delta)$$

(y ... elongation, r ... amplitude, ω ... angular frequency, t ... time, δ ... angle of phase difference)

Velocity stated mathematically is the first derivation:

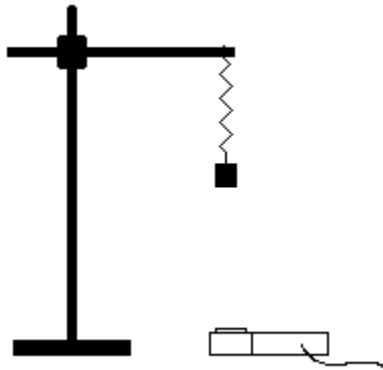
$$v = -\omega \cdot r \cdot \sin(\omega t + \delta)$$

In this exercise, we will examine a graphical display of the motion of a mass hanging from the spring using the CBR.

Equipment required:

- CBR Unit, TI-92 Calculator with Unit to Unit Link Cable
- Spring
- Hanging Mass
- Ring Stand
- Support Rod

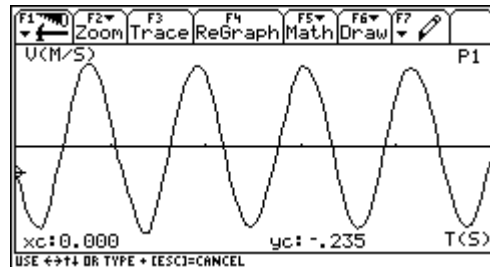
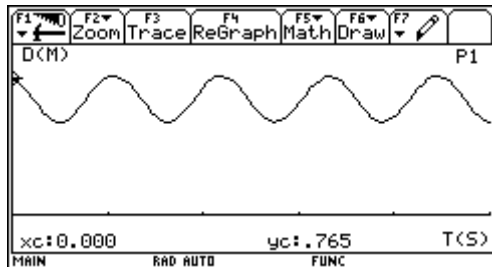
Instructions:



We set up ring stand and support rod and suspend the spring so that it is at least 1 m from the floor. We place the CBR on the floor so that it is aimed at the hanging mass.

We run the RANGER program on our graphing calculator and enter the setup instructions (Realtime = No, Time(s) = 4, Begin on = [Enter]).

We pull the mass from the resting position so that it is oscillating up and down. Then we press <Enter> to begin collecting data once the mass is moving.. Our data should look like a sine or cosine graph with at least four complete cycles of the motion (distance-versus-time plot). After pressing <Enter> there will be a menu where we can choose the velocity-versus-time plot (or the acceleration-versus-time plot).



The data has been stored in the calculator as follows:

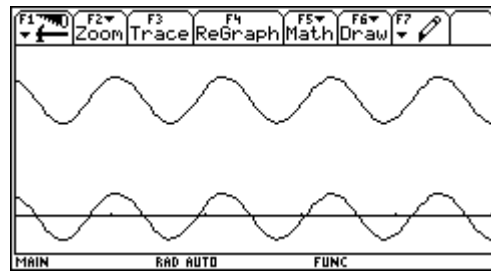
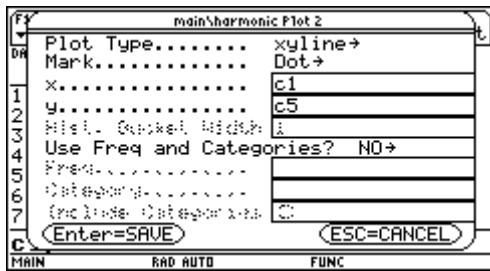
Time data is stored in L1, Distance data is stored in L2, Velocity data is stored in L3, Acceleration data is stored in L4.

The mass oscillates about the position it would have at rest. In physics, this would be called its equilibrium position. In mathematical terms, we call this the vertical shift of the cosine graph. The equilibrium position should be the average of the Y values since the mass oscillates about this position.

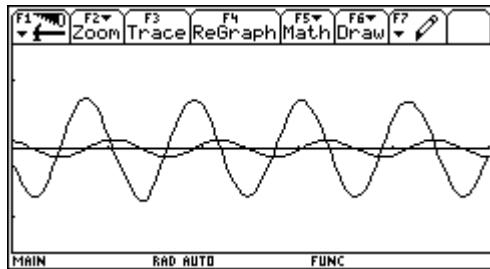
We open the "6:Data/Matrix Editor" from the APPLICATIONS menu of our TI-92 and create a new variable (e.g. "harmonic"). In the known manner we get the lists into the data editor. In L2 we find the equilibrium position (here 0.647 m). We create a fifth column with L2-0.647 and define a new plot:

	F1 Plot	F2 Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	11=t	12=s	13=v	14=a	12-.647		
	c1	c2	c3	c4	c5		
1	0.000	.765	-.235	-3.807	.118		
2	.054	.746	-.358	-2.291	.099		
3	.108	.722	-.529	-2.190	.075		
4	.161	.691	-.644	-1.619	.044		
5	.215	.656	-.693	-1.465	.009		
6	.269	.617	-.720	-.311	-.030		
7	.323	.577	-.655	2.709	-.070		
c5.Title="12-.647"							
MAIN RAD AUTO FUNC							

	F1 Define	F2 Copy	F3 Clear	F4
main\harmonic				
Plot 1:				
Plot 2:				
Plot 3:				
Plot 4:				
Plot 5:				
Plot 6:				
Plot 7:				
Plot 8:				
Plot 9:				
c5.Title="12-.647"				
MAIN RAD AUTO FUNC				



Now it is possible to compare the plots (e.g.):



s-t- and v-t-plot

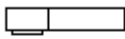
When the distance is at a maximum, the velocity is zero.

3. Bouncing Ball

Equipment required:

- CBR Unit, TI-92 Calculator with Unit to Unit Link Cable
- Ball

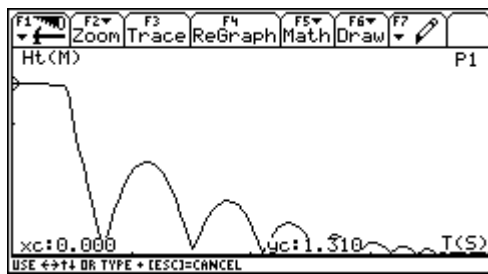
Instructions:



We will explore the rebound height of a dropped ball and develop a function that will model the rebound heights for a particular bounce. The model can be used to predict the height of the ball for any bounce.



We run the RANGER program on our calculator, choose "3:Applications" from the MAIN menu and "2:Meters". Then we select "3:Ball Bounce" from the APPLICATIONS menu.



We follow the directions on the screen. We press the **TRIGGER** key on the CBR and release the ball. The graph should have a minimum of five bounces. We use \blacktriangleright (the right arrow) to trace to the approximate vertex of the first bounce. We record the coordinates of this point in a table and repeat for more bounces.

We exit the RANGER program and open the

“6:Data/Matrix Editor” from the APPLICATIONS menu of our TI-92. We create a new variable (e.g. “ball”) and enter the coordinates of each vertex.

NEW

Type: Data→

Folder: main→

Variable: ball

Row dimension: 1

Col dimension: 1

Enter=OK ESC=CANCEL

	t	y	c3	c4	c5
1	1.118	.708			
2	1.806	.416			
3	2.322	.246			
4	2.709	.150			
5	3.053	.093			
6					
7					

c3.Title=

We create a Plot2, a scatter plot of the maximum height of each bounce versus time:

main\ball

Define Copy Clear

Plot 1: x:main\1 y:main\12

Plot 2:

Plot 3:

Plot 4:

Plot 5:

Plot 6:

Plot 7:

Plot 8:

Plot 9:

c3.Title=

main\ball Plot 2

Plot Type..... Scatter→

Mark..... Box→

x..... c1

y..... c2

Hist. Graph Width: 1

Use Freq and Categories? NO→

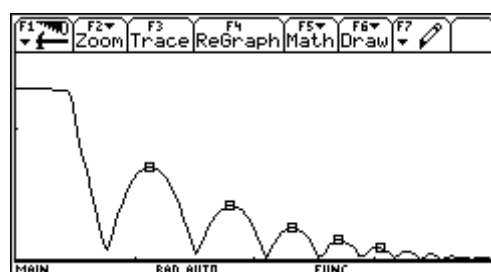
Freq.....

Category.....

(Include Category) C

Enter=SAVE ESC=CANCEL

The result appears in the GRAPH window of the TI-92 (<◀> + <R>):



We return to our data by opening the “6:Data/Matrix Editor” from the APPLICATIONS menu of our TI-92 and choosing “1:Current”. We approximate the scatter plot by the performance of an exponential regression:

main\ball Calculate

Calculation Type. ExpReg→

x..... c1

y..... c2

Store RegEQ to... y1(x)→

Use Freq and Categories? NO→

Freq.....

Category.....

(Include Category) C

Enter=SAVE ESC=CANCEL

STAT VARS

y=a·b^x

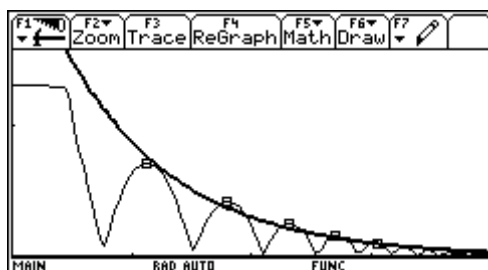
a =2.513039

b =.351654

Enter=OK

c3.Title=

The results can look like the following:



Authorities:

A Bellman, L Antinone, C Brueningsen, W Krawiec, J Randall

CBL™ System Experiment Workbook, *Texas Instruments*

C Brueningsen, B Bower, L Antinone, E Brueningsen

Real-World Math with the CBL™ System, *Texas Instruments*

C Brueningsen, W Krawiec

Exploring Physics and Math with the CBL™ System, *Texas Instruments*

L Antinone, S Gough, J Gough

Explorations: Modeling Motion: High School Math Activities with the CBR™,
Texas Instruments

C Brueningsen, E Brueningsen, B Bower

Explorations: Math and Science in Motion: Activities for Middle School, *Texas Instruments*