CLEMSON ALGEBRA PROJECT
UNIT 3: LINEAR FUNCTIONS

PROBLEM 1: WALK BY GRAPH

For this investigation, you will need your graphing calculator, the EA-100, and the motion detector. Make sure the MOTION program, along with its subsidiary programs, has been loaded on your calculator. Then, call up the program and select "WALK BY GRAPH" and "Linear." Try to match the picture shown in your viewing window. Complete this activity several times. Discuss what you have discovered about the relationship between the graph and what you need to do to match it with your walk. What are the critical elements that make the graphs linear? Use your findings to develop a general form for linear functions.

MATERIALS

Casio CFX-9850Ga Plus or ALGEBRA FX2.0 Graphing Calculator

Casio EA-100 Data Collector

Pasco Motion Detector

EXTENSIONS

Again using "WALK BY GRAPH" on the MOTION program, select other function types and try matching these graphs. Explore the differences you find among the different function types.

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ONE SOLUTION TO PROBLEM 1: WALK BY GRAPH

The MOTION program has been designed to help students to make connections among graphs, equations, and the real world, using the *x*-axis as time and the *y*-axis as distance. First, make sure that each calculator that will be used with the data collector has the series of six programs entitled “MOTION,” “ MOTION1,” “MOTION2,” “MOTION3,” “MOTION4”, and “MOTION5.” To transfer these programs from one calculator to another, make sure the calculators are connected with the supplied cable. Turn the calculators on, and

- Select “Link” from the MAIN MENU on both the receiving and sending calculators.
- Press [F2] on the receiving calculator.
- Press [F1] on the sending calculator.
- Press [F1] to select the desired programs.
- Use [F1] and the down arrow to select each of the six programs named above.
- Press [F6] to transmit.

If you get an error message, make sure the cable is securely attached to both calculators.

Before the students begin to work on the problem, the teacher should introduce the program with a demonstration for the entire class. First, all of the tools must be hooked up correctly.

- Set the switch on the top of the motion detector on wide range. Depending on the physical arrangement of the room, this may have to be reset on narrow range. This will be necessary if the motion detector picks up the wrong things along the borders of the path.
- Clear a path about 2 meters wide and 6 meters long. This will be used for a person to walk toward and away from the motion detector.
- Using the cord, attach the calculator to the EA-100 data collector.
- Turn the EA-100 on.

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- Connect the EA-100 to the motion detector with the supplied cable. The cable plugs into the sonic port on the EA-100. Set the motion detector along the walking path at a height that will “hit” the walker.
- Turn the calculator on. From the MAIN MENU, call up “Program.”
- Highlight MOTION and press EXE .

Before working on the problem, students should familiarize themselves with the program. Look at the bottom of the MOTION menu screen (see below left). N=20 indicates that 20 data points will be collected. DT=0.5 means that the points will be collected every half second (DT stands for ‘delta time’). U=[M] tells us that the units are in meters. These values can be changed by selecting OPTIONS from the menu, but it is recommended to begin with the default values shown.

Although the problem asks students to explore “WALK BY GRAPH,” to become familiar with the program, begin with option 1, “PLOT A WALK.”

- From the menu screen shown below left, press 1 and EXE .
- Follow the directions, which tell you to press the TRIGGER key on the EA-100 when you are ready to start and the EXE on the calculator when the sampling is finished. See below right.

```
?
1 PLOT A WALK
2 WALK BY GRAPH
3 WALK BY EQUATION
4 WALK MY EQUATION
5 OPTIONS     9 EXIT
N=20  DT=0.5   U=[M]
```

```
PRESS TRIGGER ON
   EA-100 TO START.
PRESS EXE WHEN
   SAMPLING IS DONE.
              - Disp -
```

After you have finished, a graph of the walk should be displayed on your calculator. The screen below shows one particular walk. First, the teacher should point out that the tick marks on the *x*-axis represent seconds and the tick marks on the *y*-axis represent meters away from the detector. The teacher should then lead a class discussion helping students to interpret the graph.

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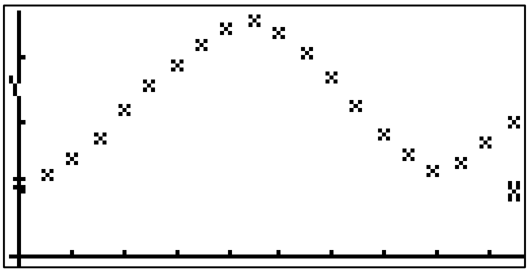

Some issues and questions that the teacher may wish the class to discuss follow.

- Let’s make sure everyone understands what a point represents. For example, what does the second point to the right of the *y*-axis represent? (One second after the trigger was pressed, which started the data collection, the walker was about 1.5 meters away from the detector.)
- Which direction did the walker move when the program started? (Away from the detector.)
- How far from the detector did the walker start? (About 1 meter, because the graph appears to have a *y*-intercept about 1.)
- What direction is the walker moving when the graph goes up? (Away from the detector – the distance is becoming greater.)
- What direction is the walker moving when the graph goes down? (Toward the detector – the distance is becoming smaller.)
- When did the walker change directions? (Approximately 4.5 and 8 seconds into the data collection – this is based on when the graph changes from increasing to decreasing or decreasing to increasing.)
- What would a straight line represent? (Motion at a constant speed.)
- What would a curved line represent? (Motion at changing speeds.)
- Could you “walk” a circle? How or why not? (No, you can’t be in two places at the same time.)
- What creates shapes that cannot be “walked”? (Answers may vary. Key ideas are the positive values in the domain and range, and that for any input there is only one output – one definition for function.)
- What does the domain refer to in this setting? (The time – 0 to 10 seconds.)
- What does the range refer to in this setting? (Distance – 0 to about 4 meters.)

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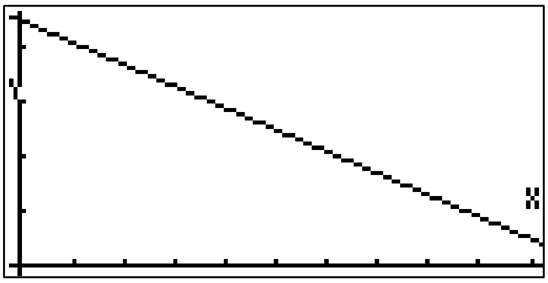
After one or two trials with “PLOT A WALK,” the class should be ready to move to the second component of the MOTION program, “WALK BY GRAPH.” Depending on the physical size of the room, the number of students, and, of course, the number of equipment set-ups available, divide the class into groups. Groups of three or four often work best, but groups of two can work too. Each person should be assigned roles. For example, for a group with four people, one person can be the “techie,” assigned to make sure the equipment is hooked up properly and the path for the walker is clear. One person can be the “trigger person,” giving the commands to the data collector and the calculator. A third can be the “commander,” telling the walker where, when, and how fast to go. The fourth person can be the “walker.” Group members should rotate through these roles.

To begin, from the MOTION menu, press [2] and [EXE] . We are interested in LINEAR functions, so press [1] and [EXE] . A graph, chosen randomly by the calculator within parameters set within the program, will appear. One such graph is shown below.



The group should discuss how to match this graph through their motion. For the graph shown above, the person should start about 4.5 meters away from the motion detector and then move towards the detector at a constant speed, reaching about .5 meters away from the detector in 10 seconds.

After the “commander” has indicated to the “walker” what to do, the “trigger person” should press [EXE] on the calculator. As before, the screen instructs the user to press the [TRIGGER] on the data collector to begin and [EXE] on the calculator after the data have been collected. Before pressing the [TRIGGER] , the group may note that the display on the data collector shows how far the person is away, so the starting point can be determined fairly accurately.

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After EXE has been pressed, the calculator displays both the original graph and the results of the "walker." After a few trials, the group should become more adept at matching the graph. If desired, they can select the option to retry a particular graph.

NOTE: If for some reason a mistake is made while collecting data and the AC/ON key is pressed to break out of the program, you will need to unplug the EA-100 and reset the equipment as described in the beginning of the module.

By using this program, students should discover the key components of linear equations. The teacher should pose the following questions for students to reflect upon and answer and then lead a class discussion concerning the main considerations of linear functions in two variables.

- The *y*-intercept is the starting point, representing the distance the "walker" is from the motion detector at time 0.
- If the graph goes up, the distance from the motion detector increases. If the graph goes down, the distance from the motion detector decreases.
- Linear functions have constant slope. This means that the rate at which the "walker" moves must stay the same throughout the entire walk.
- The rate at which the "walker" should move can be determined by two points on the graph. In our example, at time 0, the "walker" was to be 4.5 meters away from the motion detector. After 10 seconds, the "walker" was to be 0.5 meters away. In other words, the "walker," starting 4.5 meters away from the motion detector, needed to move towards the detector at a steady speed, covering 4 meters in 10 seconds. This equates to .4 meters (40 cm) every second.

The teacher can use these ideas to build toward an intuitive understanding of $y = b + ax$ and then $y = ax + b$ forms for linear equations.

- At 0 seconds, the walker should be 4.5 meters away from the detector.
- At 1 second, the walker should be $4.5 - .4$ meters away.
- At 2 seconds, the walker should be $(4.5 - .4) - .4$ or $4.5 - .4 \times 2$ meters away.
- At 3 seconds, he/she should be $((4.5 - .4) - .4) - .4$ or $4.5 - .4 \times 3$ meters away.
- Finally, at *x* seconds, the walker should by $4.5 - .4x$ meters away.

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