

*Escape!*

Version 2 for PC and Mac OS X

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## Teachers' Manual

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by Sharon Dugdale and David Kibbey

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“Escape!” was originally published as part of a package titled *Interpreting Graphs*. The current version is part of the *Green Globes & Graphing Equations* package.

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## **Introduction**

*ESCAPE!* is an activity that helps students make meaningful interpretations of line graphs of physical phenomena. This computer activity can help students develop skills and concepts useful for dealing with graphs in any area.

### **Intended Audience**

This program is appropriate for a wide range of courses involving graphing. This activity is recommended for students at the secondary level or even the college level, but students in the intermediate grades who have had some introduction to graphing concepts can also benefit from using this program.

### **Brief Program Description**

*ESCAPE!* is a game in which students use graphs as diagnostic tools in a dynamic situation. The graphs provide information about the movement of bank robbers on a coordinate grid. The student uses this information to decide where to set blockades to trap the bank robbers.

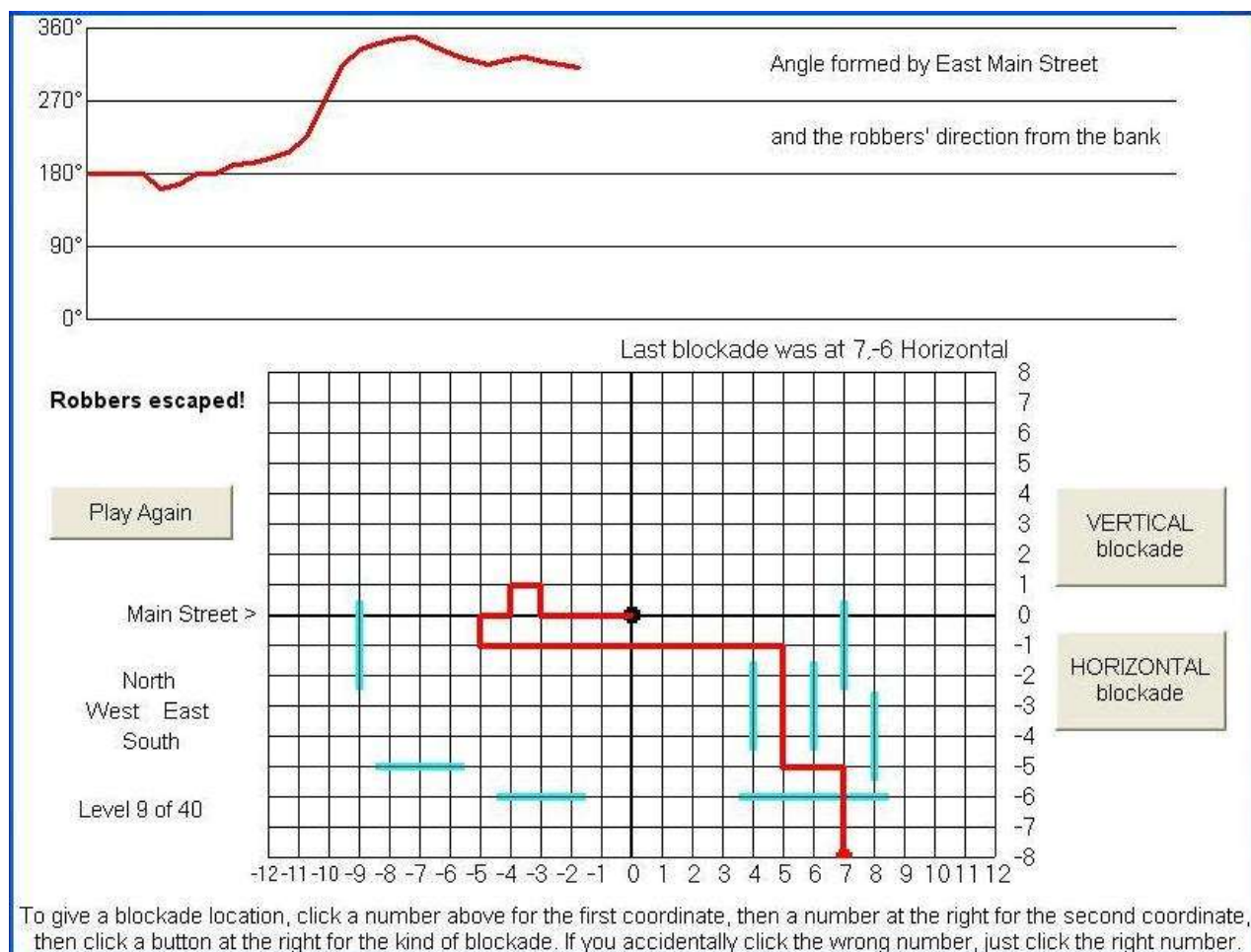
Prerequisites: Be able to plot points on a coordinate grid, and have a basic idea of what a graph is.

Skills: Use graphs as diagnostic tools.

Grade Level: 6 – adult (lower than 6 if prerequisites are met)

Time Required: open-ended

## Escape!



(In this manual, *Escape!* screen displays have a white background for printing. On the computer, the displays have a black background to maximize contrast.)

*ESCAPE!* is a game in which students use graphs as diagnostic tools.

**Prerequisites:** Be able to plot points on a coordinate grid, and have a basic concept of a graph.

**Skills:** Use graphs as diagnostic tools.

**Grade Level:** 6 – adult (lower than 6 if prerequisites are met)

**Time Required:** open-ended

**Objectives:** Translate changes in a graph into the related changes in an event. Decide what a graph tells you, what it does not tell you, when and what to estimate, and when specific function values are important.

## **Program Overview**

A city map is represented by a rectangular coordinate grid. Bank robbers try to escape from a bank at the center of the city to the city limits at the edge of the grid. Students try to trap the robbers by setting blockades.

The robbers have a head start. After this head start, they change direction only when they approach a blockade placed directly ahead of them. The robbers' path is not displayed until after the game ends. Students must make blockade decisions based on information obtained from a graph of the robbers' movements.

Students choose one of three graphs (described in detail below). The graph may provide only part of the information needed to specify the robbers' position. Students must decide what the graph tells them, what it does not tell them, and how to use this information to set blockades.

There are three possible outcomes to each game:

- 1) The robbers escape by reaching the city limits.
- 2) The player catches the robbers by trapping them with blockades.
- 3) If the robbers have not escaped by the time the graph runs out of screen space, their car is declared to be out of gas, and the student wins.

Each game has a difficulty level, which is the number of blocks that the robbers get for their head start. The game starts at level 3. At the end of each game, the difficulty level for the next game adjusts up or down, depending on the student's performance. The highest level is 40. For higher levels, the robbers move slightly faster.

## **The Introduction**

The Introduction section of the program explains the scenario. The road map of the city is labeled with the bank at the center, Main Street the x-axis, and the directions North, East, South, and West indicated.

The blockades are set by entering the coordinates of a point. The coordinates are the center of a blockade that covers three intersections. The coordinates are displayed as two numbers separated by a comma. The student enters the coordinates by clicking a number below the grid for a horizontal coordinate, a number to the right of the grid for a vertical coordinate, and then clicking either the Vertical Blockade button or the Horizontal Blockade button.

The program displays the coordinates of the student's previous blockade for reference while the student is entering new coordinates.

The robbers have a head start. During that short time, the robbers change direction to confuse the pursuit. After that, the robbers head for the city limits, changing direction

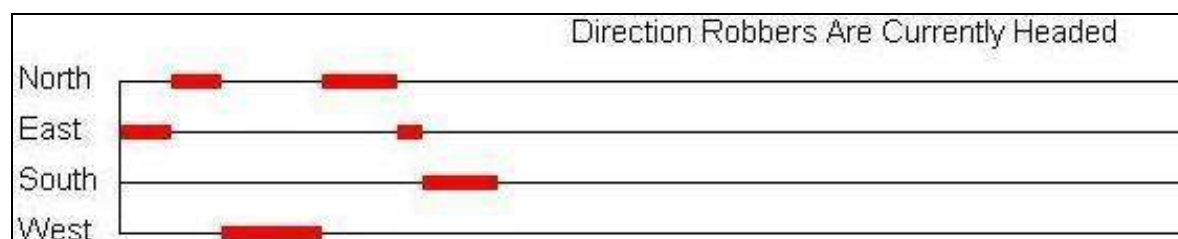
only when they see a blockade in their path. (The robbers can see ahead only a few blocks.) Blockades must be placed in front of the robbers to stop them. Blockades placed behind the robbers have no effect.

There is a "transmitter" in the money bags the robbers took. Information about the robbers' location is provided in a graph. The student can choose which graph to use to play the game:

1. the direction the robbers are currently headed
2. the robbers' distance north of Main Street, measured in city blocks
3. the angle the robbers' location makes with East Main Street

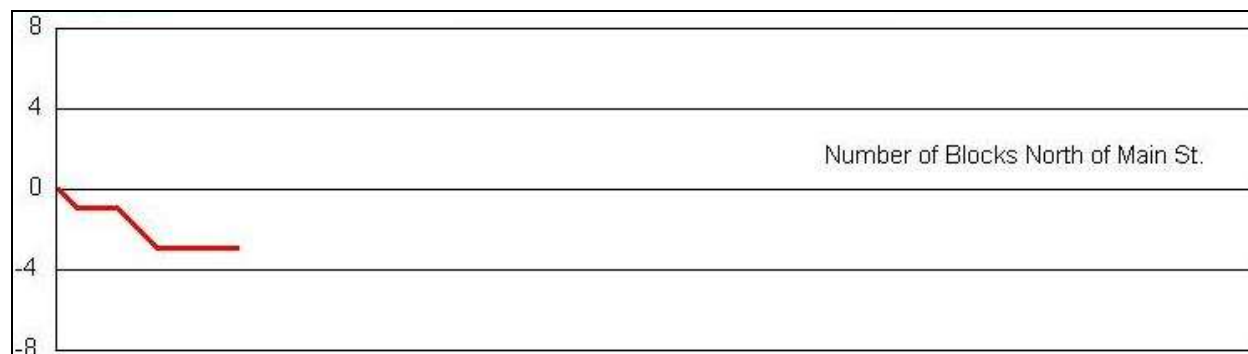
### Three Kinds of Graphs

#### 1. Direction Currently Headed



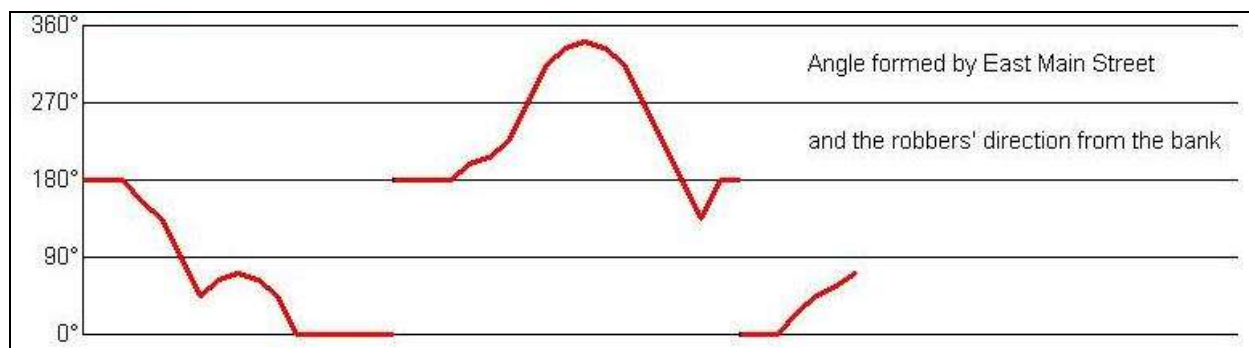
This graph is a set of horizontal line segments showing the direction the robbers are moving: north, east, south, or west. There are four horizontal lines, each representing one direction. When the robbers are traveling north, a bar on the north line is shown.

#### 2. Number of Blocks North of Main Street



This graph displays the robbers' distance north of Main Street. Main Street is the x-axis of the grid. The distance is shown in blocks. Positive numbers of blocks indicate positions north of Main Street, negative numbers indicate positions south of Main Street.

### 3. Angle with East Main Street



This graph shows the angle between the robbers' location and East Main Street (the positive part of the x-axis). This graph includes curves and discontinuities, and it is probably the most difficult for students to interpret. The angle graphed is the angle formed by East Main Street (the positive x-axis) and a line from the center of town to the robbers' current location. It is not the angle that the robbers turn along their path.

### Classroom Use

#### Preparation

Students need skills in relating points on the grid to their coordinates. Playing the game will strengthen their ability to match coordinates to the point where they want to place the blockade. However, the pace of the game and the need to interpret the graph to make decisions mean that students do not have much time to decide coordinates for each blockade.

To successfully play this game, students must perform several actions:

- ✓ read and interpret the graph
- ✓ decide on a strategy to use
- ✓ decide the coordinates of the next blockade, and select them
- ✓ decide the direction of the blockade, and select it

Individual students may have difficulty initially doing all these activities under the time constraints of the game. Students may prefer to begin by working in pairs or by watching others play the game.

If any students are unsure about setting blockades and interpreting the graphs even after playing some games, worksheets 1 through 4 provide detailed practice exercises.

Rather than discussing the graphs in detail with the class, it is suggested that students first play the game. After they have had first-hand experience using the graphs, a discussion and evaluation of the graphs is more meaningful. See the Follow-Up section for discussion ideas.

This game is not easily won, especially at higher levels. Emphasize that lost games provide valuable information to use in future games. Students should expect the robbers to get away several times as the students learn to play the game.

### **Using the Program**

Two or more players can successfully team up to play the game. The pace of the game requires that decisions be made promptly, but there is more opportunity for discussion when the robbers' path is displayed at the end of the game.

Students playing *ESCAPE!* are doing more than just reading a graph. They are using the graph as a diagnostic tool. The graph provides important information when the robbers react or fail to react to blockades.

Like many diagnostic tools, the graphs here may describe only one aspect of the situation. Part of the students' problem is to decide what to look for in the graph and how much accuracy is needed. Sometimes the current value of the graph is the important element. Sometimes the general range of recent values is all that is needed. Sometimes the direction in which the graph is changing is the important part.

Students must decide what information is missing from the graph and how to place blockades to reduce the ambiguity.

### **Follow-Up**

Worksheets 5, 6, and 7 provide questions to help students analyze and evaluate the graphs and the information they present. They are intended for use after students have played the game enough to be reasonably experienced at it. These worksheets are appropriate for all students and are useful preparation for the class discussion.

Group discussions are valuable after everyone has had experience with the game. Discussion might follow the use of each type of graph or might be saved until all three graphs have been explored.



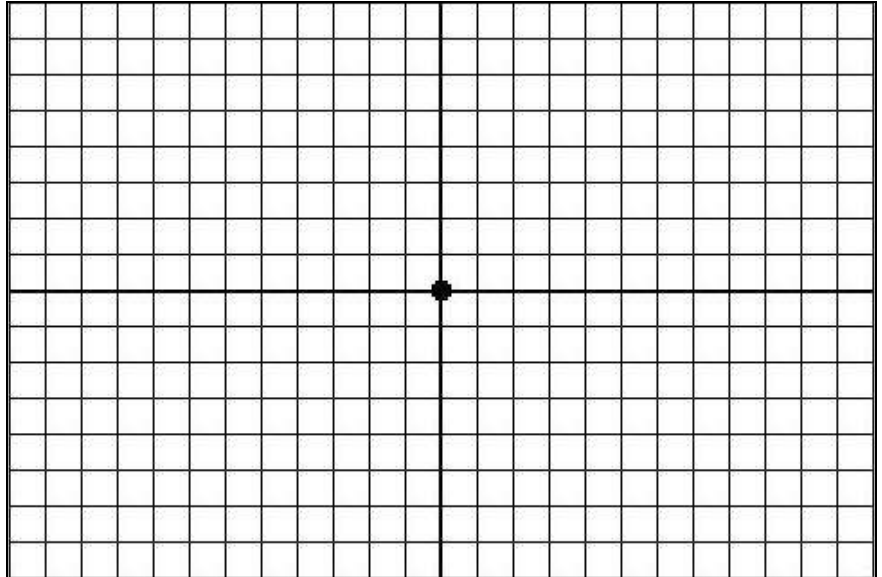
## Worksheet 1 – Escape! Practice: Setting Blockades

Blockades are placed on the map by entering a set of coordinates. The coordinates mark the center of the blockade.

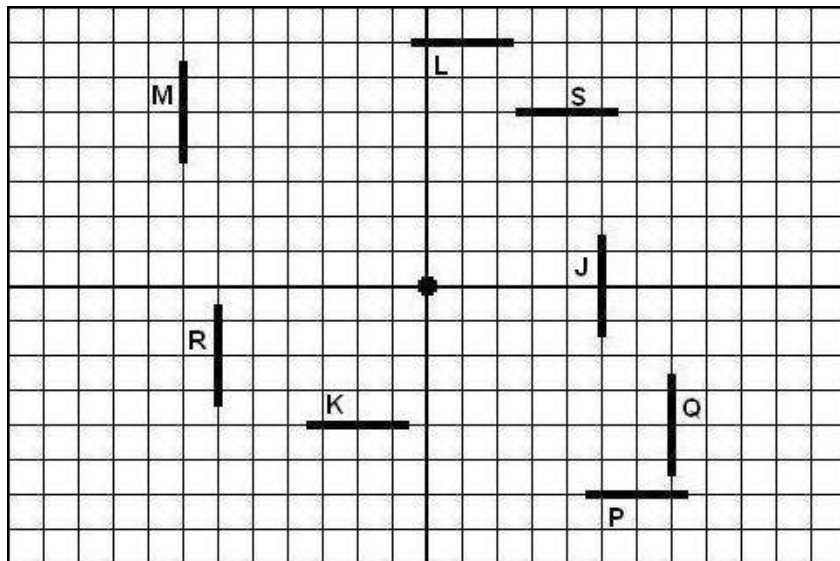
Each blockade covers three intersections (or three sets of coordinates).

Here are some typical blockade commands. Draw each blockade on the grid and label it with a letter.

- A. 4, 6 Vertical
- B. 4,-6 Vertical
- C. -3, 0 Vertical
- D. -3,-8 Horizontal
- E. 1, 7 Horizontal
- F. -7,3 Horizontal
- G. 0,-4 Horizontal
- H. -8,-8 Vertical

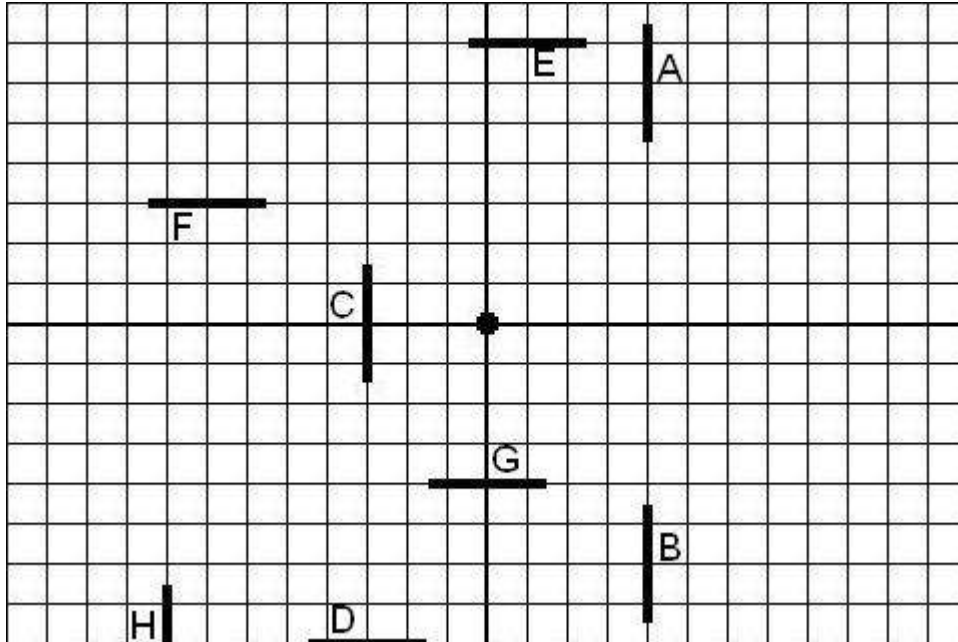


Look at the blockades below. Write a command to create each blockade.



- J. \_\_\_\_\_
- K. \_\_\_\_\_
- L. \_\_\_\_\_
- M. \_\_\_\_\_
- P. \_\_\_\_\_
- Q. \_\_\_\_\_
- R. \_\_\_\_\_
- S. \_\_\_\_\_

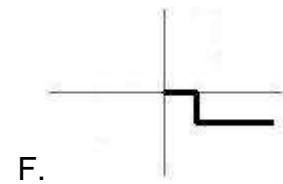
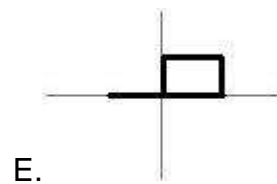
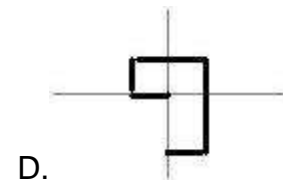
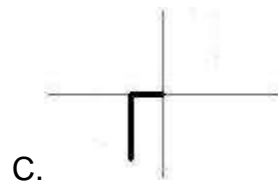
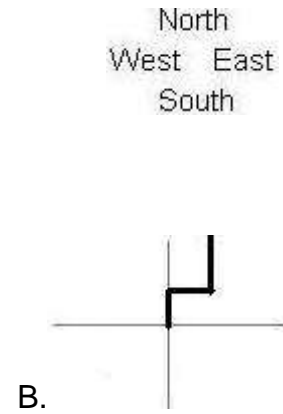
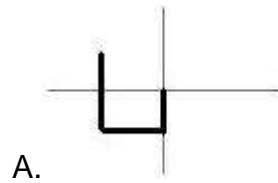
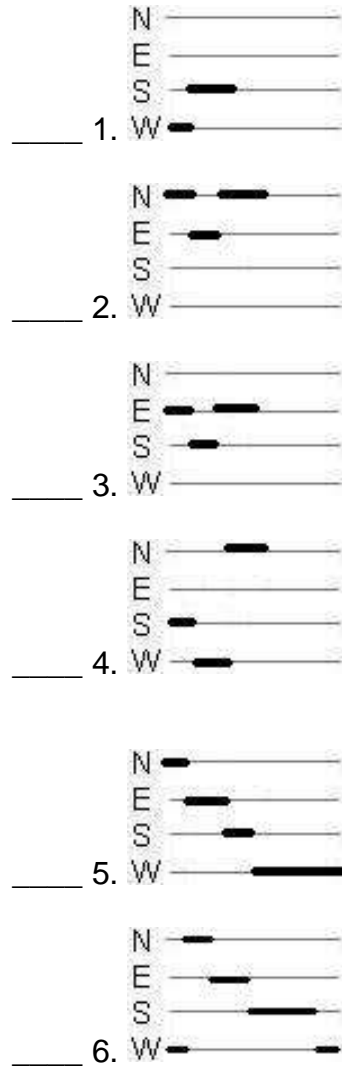
*ANSWERS Worksheet 1 – Escape!*  
*Practice Setting Blockades*



- J. 5, 0 Vertical
- K. -2, -4 Horizontal
- L. 1, 7 Horizontal
- M. -7, 5 Vertical
- P. 6, -6 Horizontal
- Q. 7, -4 Vertical
- R. -6, -2 Vertical
- S. 4, 5 Horizontal

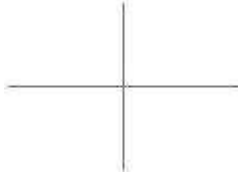
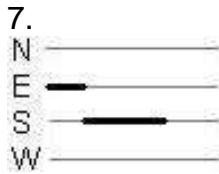
Worksheet 2 (page 1 of 2) – Escape! Practice: Direction Currently Headed

Match each of the graphs on the left with the path it represents.

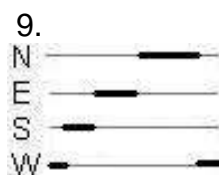
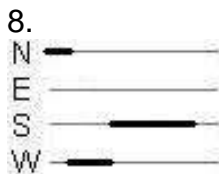


Worksheet 2 (page 2 of 2) – Escape! Practice: Direction Currently Headed

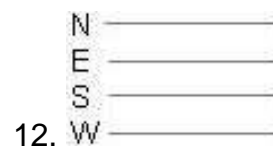
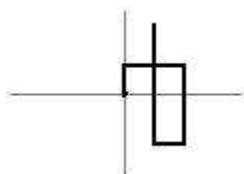
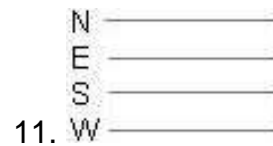
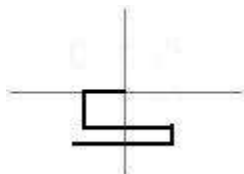
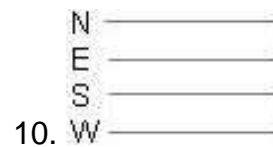
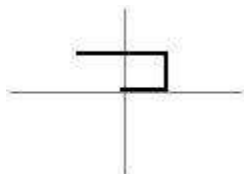
For each of the graphs below, draw a path that fits the graph.



North  
West East  
South



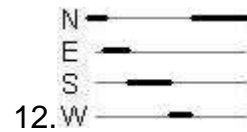
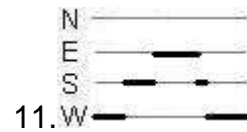
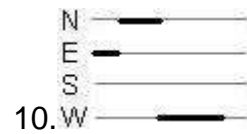
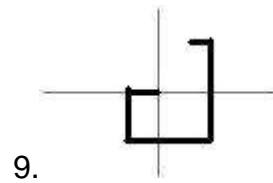
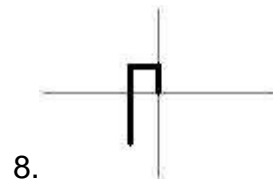
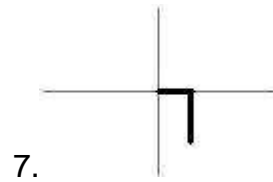
For each of the paths below, draw a graph that fits the path.



*ANSWERS Worksheet 2 – Escape!*  
*Practice: Direction Currently Headed*

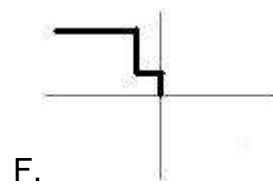
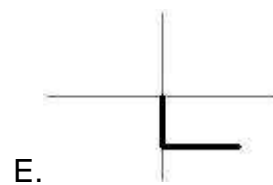
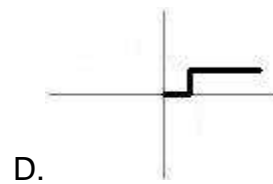
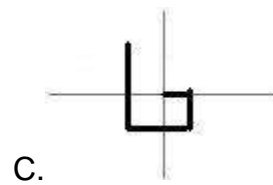
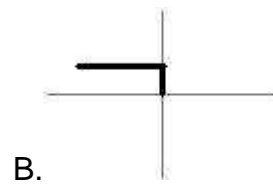
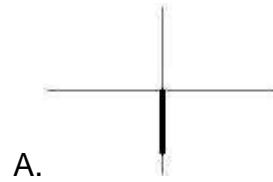
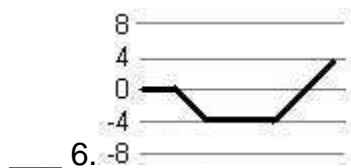
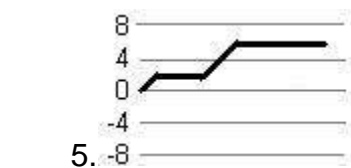
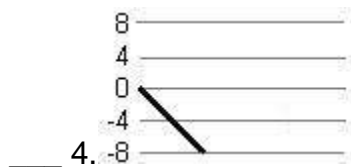
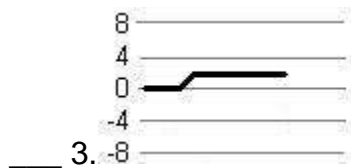
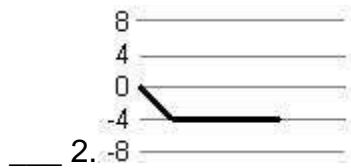
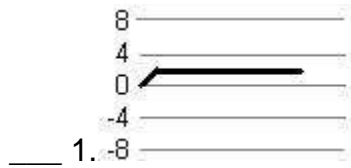
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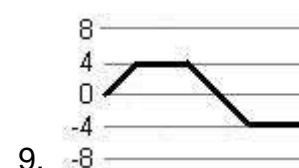
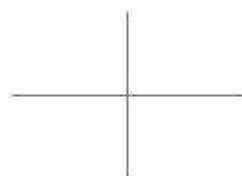
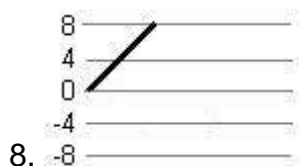
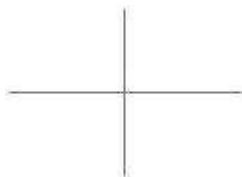
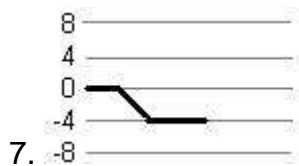
Worksheet 3 (page 1 of 2) – Escape! Practice: Distance North of Main Street

Match each of the graphs on the left with the path it represents.

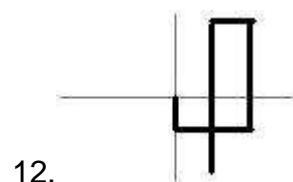
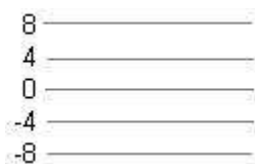
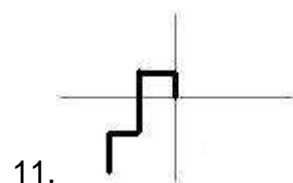
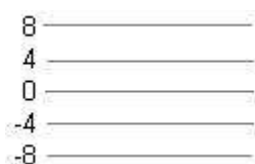
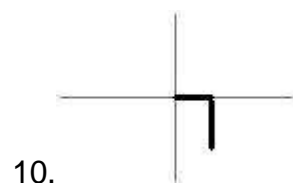


Worksheet 3 (page 2 of 2) – Escape! Practice: Distance North of Main Street

For each of the graphs below, draw a path that fits the graph. Is there more than one possible path for each graph?



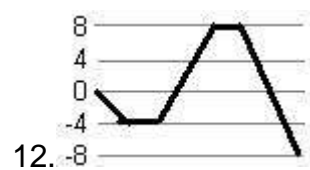
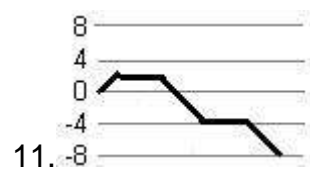
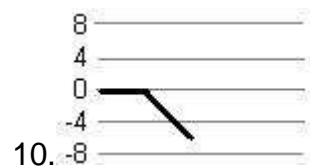
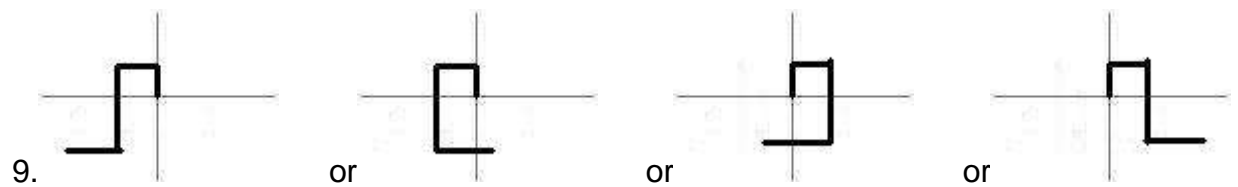
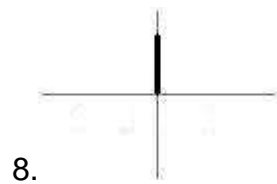
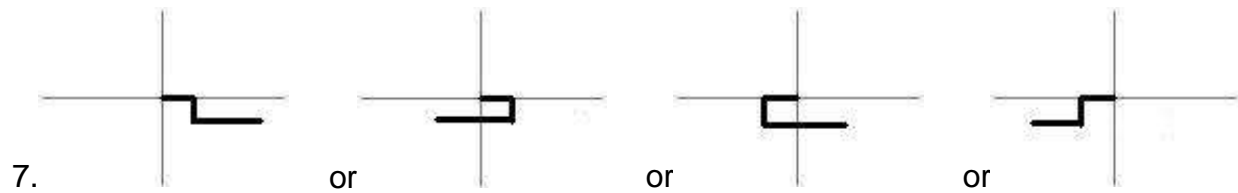
For each of the paths below, draw a graph that fits the path.



*ANSWERS Worksheet 3 – Escape!*  
*Practice: Distance North of Main Street*

Page 1:      1- B   2- E   3- D   4- A   5- F   6- C

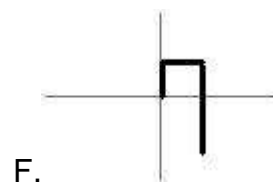
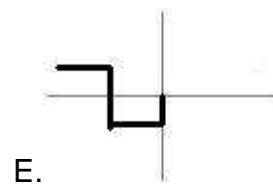
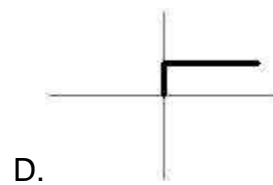
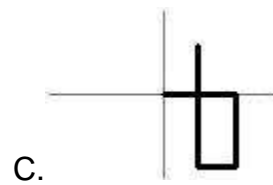
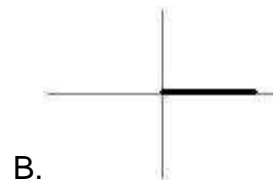
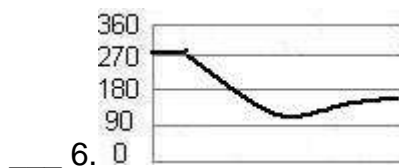
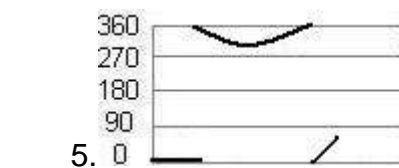
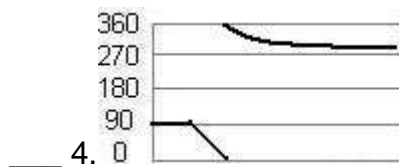
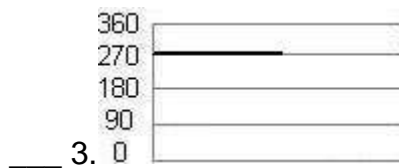
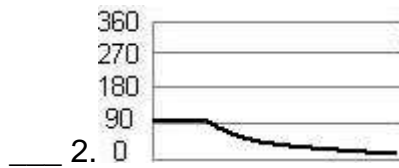
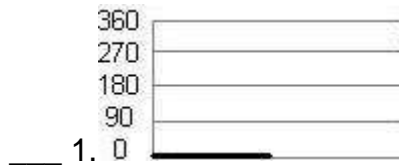
Page 2:





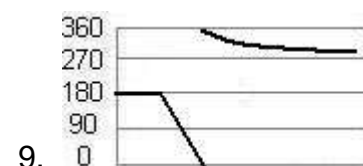
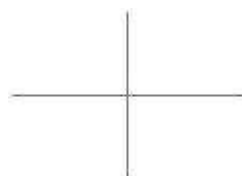
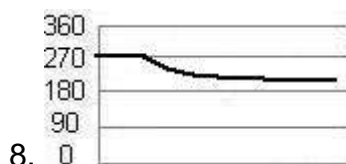
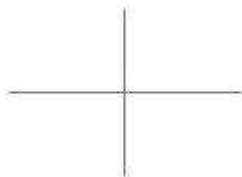
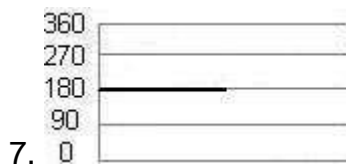
Worksheet 4 (page 1 of 2) – Escape! Practice: Angle with East Main Street

Match each of the graphs on the left with the path it represents.

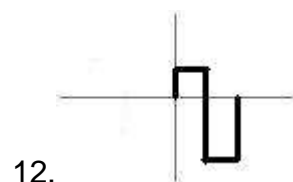
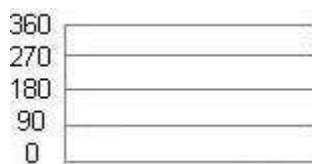
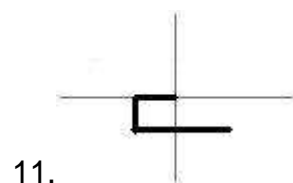
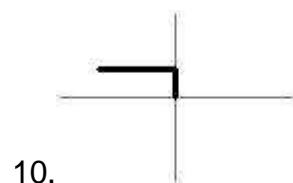


Worksheet 4 (page 2 of 2) – Escape! Practice: Angle with East Main Street

For each of the graphs below, draw a path that fits the graph. Is there more than one possible path for each graph?



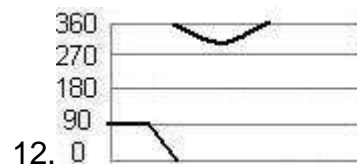
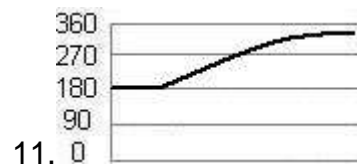
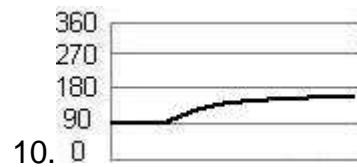
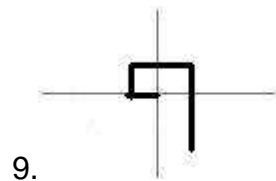
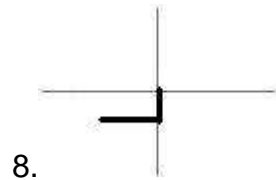
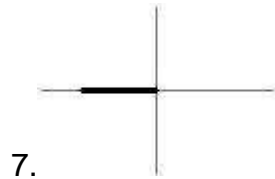
For each of the paths below, draw a graph that fits the path.



*ANSWERS Worksheet 4 – Escape!*  
*Practice: Angle with East Main Street*

Page 1:      1- B   2- D   3- A   4- F   5- C   6- E

Page 2:



*Worksheet 5 – Escape! Follow-up: Direction Currently Headed*

- 1a. After the robbers' head start, suppose the robbers keep moving in the same direction after you have set blockades. What does that tell you about the blockade locations?

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- 1b. After the robbers' head start, what does it mean if the robbers change direction after you set your third blockade?

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2. Suppose the robbers get a head start of 20 blocks. Give an example of useful information about the robbers' location that you could get from the graph, besides the direction they are currently headed.

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3. Suppose the robbers have gone twice as far east as they have gone north, with no moves south or west. What can you say about their location?

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4. Suppose the graph had a scale of numbers on the horizontal axis. How could you compute the robbers' location?

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*ANSWERS Worksheet 5 – Escape!*  
*Follow-up: Direction Currently Headed*

- 1a. The robbers do not see any blockades in the direction they are currently headed. If there is a blockade ahead of the robbers, it is too far ahead for them to see it.
- 1b. The robbers saw one of your three blockades ahead. (The blockade they saw is not necessarily the last blockade you placed.)
- 2. For example, if the robbers' total distance heading east appears to be greater than their total distance heading west, then the robbers are in the eastern half of the city.

A similar example: If the robbers' total distance heading east is much greater than their total distance heading west, then the robbers are close to the city limits at the right edge of the grid.

There are other examples.

- 3. The robbers' location is on a line through the center of the city at (0,0) and through the point (2,1). You don't know how far the robbers are from the center of the city. Their location is either (2,1), (4,2), (6,3), (8,4), or (10,5), if they have not escaped.
- 4. If the robbers' current location is the point (x,y) on the city grid, then  
 $x = \text{total distance traveled east} - \text{total distance traveled west}$   
 $y = \text{total distance traveled north} - \text{total distance traveled south}$

If there was a scale of numbers on the horizontal axis, and the robbers gave you enough time before escaping, then you could measure those total distances to compute x and y.

*Worksheet 6 – Escape! Follow-up: Distance North of Main Street*

- 1a. Does this graph tell you exactly where the robbers are located?

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If not, what information is missing?

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- 1b. Could the graph of a path east of the city center look the same as a graph of a path west of the city center? Why or why not?

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- 2a. Does the graph usually determine a unique path? \_\_\_\_\_

- 2b. Are there situations where the graph determines only one path? \_\_\_\_\_

If so, give an example. If not, why not?

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- 3a. Suppose the graph shows the robbers moving 4 blocks north from the center of the city. Then they make 5 more moves all at a distance of 4 blocks north of Main Street. What are some possible paths of the robbers?

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- 3b. In problem 3a above, what do you know about the robbers' location?

*ANSWERS Worksheet 6 – Escape!*  
*Follow-up: Distance North of Main Street*

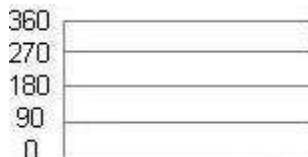
- 1a. Not usually. The graph does not tell you how far the robbers are east or west of the center of the city (the x coordinate).
- 1b. Yes, the graphs could look the same. The graph shows a robbers' move to the east the same as a robbers' move to the west.
- 2a. Not usually.
- 2b. Yes. Any graph that includes only movements north and south determines a unique path. For example, if the robbers move 3 blocks north and 2 blocks south.
- 3a. 4 north + 5 east  
4 north + 4 east + 1 west  
4 north + 3 east + 2 west  
4 north + 2 east + 3 west  
etc.  
There are 32 possible paths. (  $32 = 2^5$  )
- 3b. The robbers' location is either (-5,4) or (5,4), or between those two points.

*Worksheet 7 – Escape! Follow-up: Angle with East Main Street*

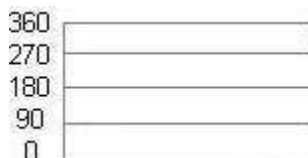
1. Does the graph give you enough information to precisely determine the robbers' location? \_\_\_\_\_ If not, what other information do you need?

\_\_\_\_\_

- 2a. Suppose the robbers move 4 blocks north. Then they see a blockade ahead and turn south. They head south until they hit the city limits. Draw the graph.



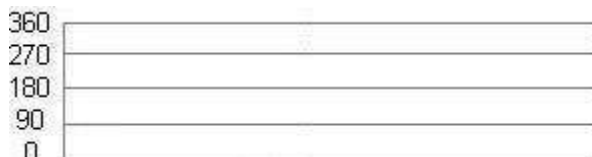
- 2b. Draw a graph where the robbers are crossing East Main Street.



- 3a. If the graph is zero, does this mean that the robbers are heading east?  
\_\_\_\_\_ Why or why not? \_\_\_\_\_

- 3b. If the graph is zero for two successive moves, what can you say about the robbers' location and the direction they are headed? \_\_\_\_\_

- 4a. Suppose the robbers move one block north of Main Street, turn east, and continue east past the city limits without stopping. Draw the graph below.



- 4b. Will the graph in 4a ever have a value of zero? \_\_\_\_\_

- 4c. What is this behavior called in mathematical terms? \_\_\_\_\_

- 5a. Suppose the robbers are moving south, toward the bottom of the screen. Can you predict whether the graph will be moving down or moving up? \_\_\_\_\_

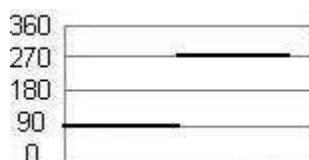
- 5b. In what situation are the robbers moving toward the bottom of the screen with the graph remaining constant? \_\_\_\_\_



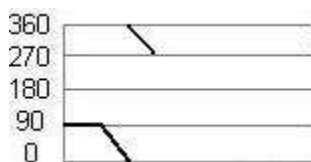
ANSWERS Worksheet 7 – *Escape!*  
 Follow-up: *Angle with East Main Street*

1. No. You need the distance from the center of the city (the polar r-coordinate) or the x and y coordinates.

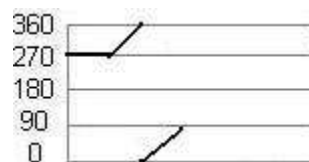
2a. The graph has a value of 90, then a discontinuity on a jump to 270.



2b. The graph has a discontinuity on a jump from 0 to 360 or 360 to 0.



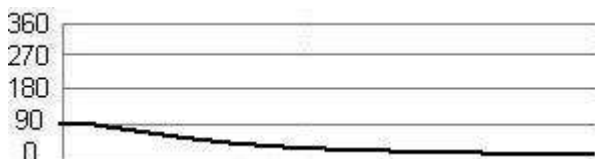
or



3a. No. They may be crossing Main Street while heading north or south.

3b. They are on East Main Street, heading either east or west.

4a.



4b. No.

4c. East Main Street is an asymptote of the graph.

5a. No, it depends on whether the robbers are in the west half of the city or in the east half of the city.

5b. The graph is constant if the robbers are directly south of the center of the city, and moving south.