TEACHERS NOTES: The Perplexing Power Pole Puzzle

Background:

Students are challenged to connect a power plant to a number of cities on a 2D grid using the least total length of wire. This is an analog to the real-world problem faced by designers of power grids, highways, and distribution networks.

Students will build skills using the Pythagorean Theorem, spatial visualization, and trial and error problem solving. Using a calculator, a first attempt solution can easily be constructed and measured in a 1-hour class period. As a multi-day homework assignment, students will have the time to investigate refinements yielding lower total lengths. Power pole placement is the key.

This puzzle belongs to the class of problems knows as NP-complete. The "NP" stands for "non-deterministic polynomial time", meaning the time required to find a solution using a computer cannot be determined from the problem. No efficient algorithms beyond trial and error exist for solving NP-complete problems. But in some cases, general strategies have been discovered.

For additional research, related problems include the Euclidean Minimum Spanning Tree and the Travelling Salesman Problem, both of which generate extensive online discussion.

In this particular version, solution attempts can be guided by the fact that optimal locations for power poles use 3 wires (1 input, 2 output), and those 3 wires separated by angles of 120° (see PPPP-solution.docx for an example). You can tell your students this ahead of time, or you can allow it to emerge as a pattern in their solutions, and comment on that pattern during review.

Whether you use PPPP-sample.docx, or generate your own puzzle from PPPP-template.docx, student solutions should converge on a minimal value for the total wire length. For the five city sample puzzle, we're reasonably certain that 42.77 miles is the solution. As the number of cities increases, the solution becomes less easily deterministic.

If you have any programming savants in your class, you might offer this problem to them as an exercise in computer problem-solving.

Using the Template:

You can easily generate your own puzzles from the template. Just below the Total Length box at upper right are three separate text boxes for the ■ ● ▲ symbols. Simply can copy and paste these into the grid to create new versions of the puzzle and its solution.

If you decide to create your own puzzles, consider experimenting with:

1. more than one power plant
2. one power plant in the center of the grid with cities in all directions
3. multiple city clusters

The Perplexing Power Pole Puzzle

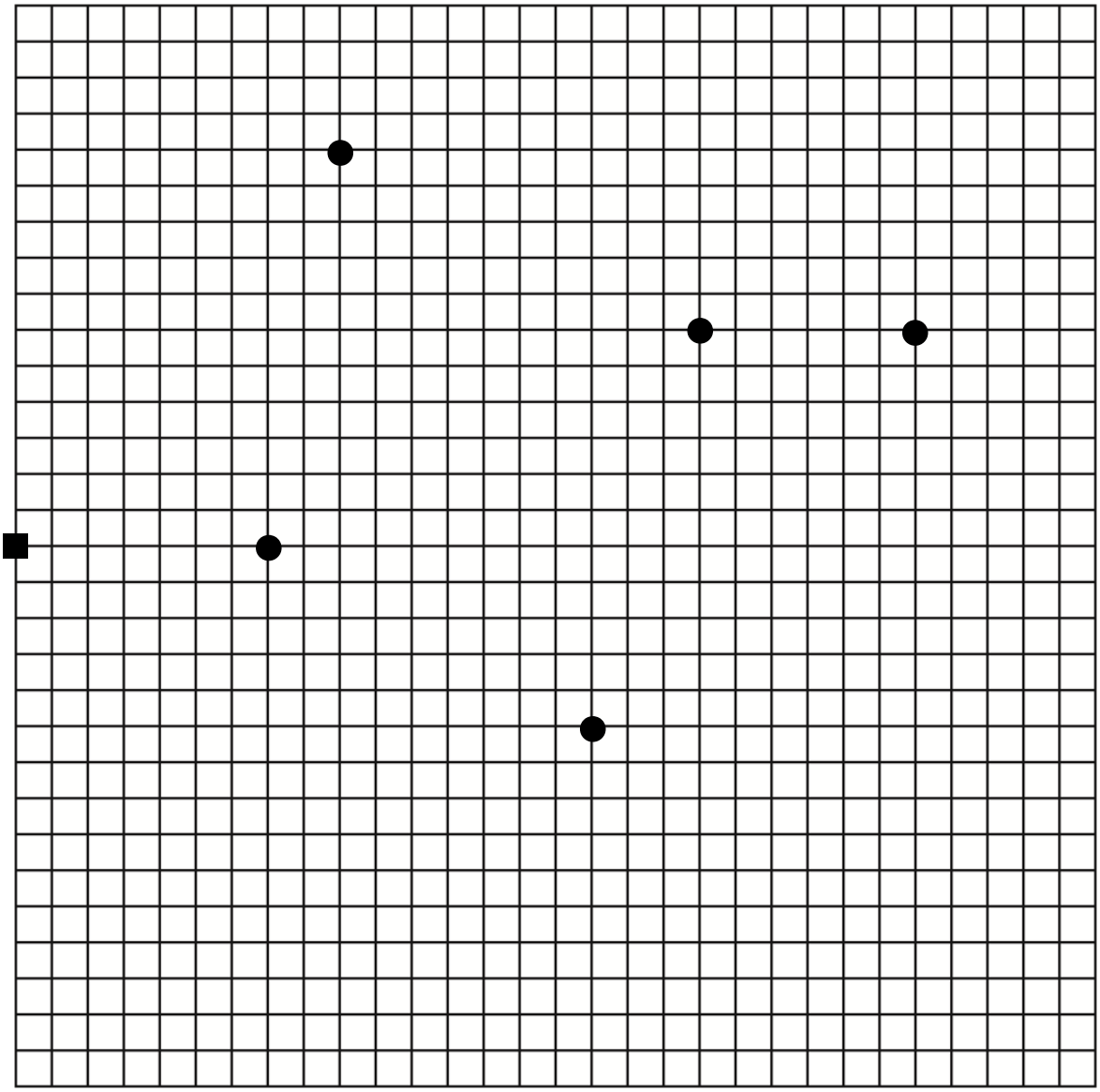
Name: _____
Class: _____
Date: _____

Total Length = _____ miles

Instructions:

The map below shows a power plant (■) and several cities (●). 1 block = 1 mile. Your job is to connect the power to all the cities using the shortest total length of wire. You may use power poles (▲) to connect wires outside a city. Here are the rules you must follow to solve this puzzle:

1. Draw your wires as straight lines on the map.
2. Wires can only connect at a city or a power pole.
3. Power poles can only be located at a grid intersection.
4. Hint: You will need at least one power pole to minimize the wire length.
5. Use the Pythagorean Theorem to calculate the length of each wire: $C = \sqrt{A^2 + B^2}$
6. Label each wire with its length (to two decimal places) and write the total length in the answer box.



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