Electric Utility Poles

Math/ Physics Grades 9-12 Nov. 29, 2009

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Lesson Overview

- Students will be introduced to the power distribution industry through pictures, narration and geometry involved in setting utility poles.

Materials Included in this Lesson

- PowerPoint Introduction
- Information Sheet
- Question Sheet
- Geometry tool for finding heights
- Quiz

Additional Materials Needed for this Lesson

- LCD Projector
- Calculators

Skills the Student will Learn

- Students will know vocabulary terms and be able to identify parts of a typical utility pole
- Students will learn similar triangles method of finding heights
- Students will learn right angle method of finding heights

Student Deliverables

- *Students will complete worksheets of math problems involving finding heights of poles*

Activity Part One: Slideshow

- Present slideshow of electric utility poles, lineman, etc.
- Present Overview of "Setting Utility Poles" document
- Supply students with question sheet to be filled in during the learning process
- Students will learn two methods of finding heights

Activity Part Two: Walk on Campus

- Students will walk to several utility poles on campus and observe their various parts
- Students will use tools to determine the height of utility poles
- Students will complete math worksheet determining height of poles using formulas
- Students retention will be assessed using vocabulary quiz

Activity Part Three: In Classroom

- Students will work math problems on worksheet consisting of problems involving finding heights.
- Students will complete vocabulary quiz

Enrichment Suggestions

- Some Electrical Utility Companies have public displays suitable for student field trips. Some will schedule tours of their facilities.

State Standards Met

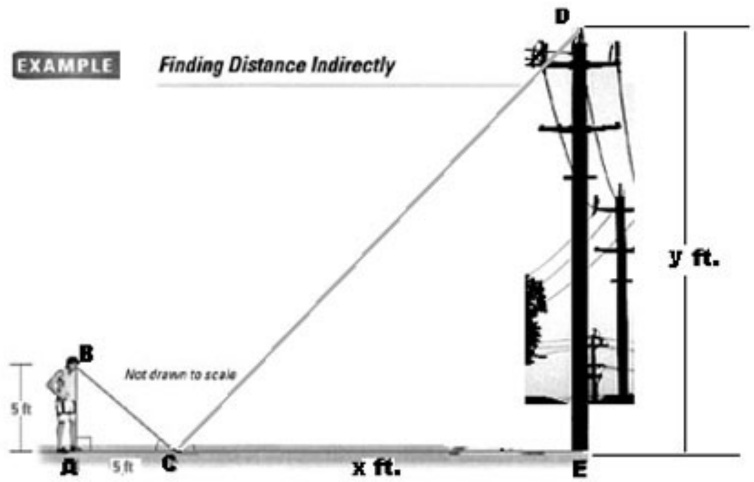
- Algebra I: 2.0 Geometry: 3.0 Trigonometry 4.0

Lesson Plan Relevance To Externship

Excellent job opportunities and career choices for interested students. This lesson could guide their career choice after high school or their educationally direction in college.

Postor Project
Rubric

Poster	1. Exceeds Expectations	2. Meets Expectations	3. Approaches Expectations	4. Fails to meet Expectations
Content	Numerous examples	Several examples	Few examples	No examples
Asthetics	Neat and Attractive	Somewhat neat and attractive	Sloppy, not presentable	Nothing
Educational value	Very informative	Somewhat informative	Little information	No information
Time and Effort demonstrated	High	Medium	Low	Nothing



SOLUTION

Due to the reflective property of mirrors, you can reason that $\angle ACB \cong \angle ECD$. Using the fact that $\triangle ABC$ and $\triangle EDC$ are right triangles, you can apply the AA Similarity Postulate to conclude that these two triangles are similar.

Triangles ABC and CED are both
90-45-45 degree triangles.
The two triangles, ABC and CED,
are similar in shape. The legs of small the
triangle are congruent. The legs
of the larger triangle must also be congruent.
We can easily measure the distance X on the ground.
We use this to determine the height of the pole.
Since x = y. the length from the observer to the pole
is the same as the height of the pole.

Discussion Questions

1. What is the proper name for a pole?
2. How tall is the pole?
3. How far in the ground is the pole buried?
4. Is it set in concrete?
5. How is the required diameter determined
6. What kind of stresses do poles bear?
7. What kind of wood is the pole?
8. When is a metal pole preferred?
9. Is the pole treated with creosote?
10. How can we determine the height using similar triangles and pacing.
11. How can we determine the length of our pace?
12. Can we average our estimated for a more accurate answer?
13. How large is the diameter of the pole?
14. Are there any marking on the pole?
15. Is there a ground wire?
16. Is there a lighting wire?
17. Is there a tap that feeds an underground system?
18. How many wires are strung on the pole?
19. What is their configuration?
20. Is it a one, two or three phase system?
21. What is the line voltage the pole carries?
22. What is the range of voltages on a variety of poles?
23. Are there phone wires or cable wire on the pole?

24. Are there guy wires?
25. Where are they attached to the pole?
26. How are they anchored?
27. What kind of insulators are on the poll?
28. Are there jumpers on the pole
29. Is there a switch?
30. Is there a transformer?
31. How would a worker get to the top of the pole for service?
32. How far apart are poles located?
33. How tight are the wires pulled?
34. What is the name of the curve of the wires between poles?
35. What harm might birds or other animals do?
36. What kind of behavior might be dangerous around wires?
37. Are trees a problem?
38. Are the wires insulated?
39. How thick are the wires?
40. The wires are made of what metal?
41. Why are not all wires buried?
42. What is the life expectancy of the utility pole?
43. Who checks them and how often?

1. _______
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12. _______
13. _______
14. _______
15. _______
16. _______

A. Power meter
B. Wind power
C. Solar array
D. Spool truck
E. Hydropower
F. Control center
G. Pole with transformer
H. Substation
I. Pole with guy wire
J. High voltage lines
K. Cross section of bundled cable
L. Power plant
M. Tower crew
N. Insulated cable
O. Metal pole
P. Bucket truck

Utility Pole

Utility poles, sometimes called telephone or telegraph poles, support a variety of overhead wires and cables. Their primary purpose is to carry electric power lines, but they may also carry communication cables such as fiber optic cable and related equipment such as transformers and street lights. Utility poles are commonly used to carry two types of electric power lines: distribution lines and subtransmission lines.

Distribution lines carry relatively low voltage electric power from local substations to customers. Distribution lines may be strung from utility poles or buried under ground at considerable extra expense. Voltages range from 5 to 35 kilovolts (kV's) for distances up to thirty miles. At a service drop (on or near the customer's premises) a transformer steps the voltage down to the lower voltage of 240/120 volts used by the customer.

Subtransmission lines carry higher voltages, from 50 to 100 kV, from regional substations to local substations, for distances up to 60 miles.

Transmission lines carry the highest voltages – 200 to 500kv. They are usually not supported by poles but by metal transmission towers.

For economic or practical reasons distribution lines may be strung on the same pole as subtransmission lines but mounted under the higher voltage lines, a practice known as "underbuild."

The standard utility pole is about 40 ft long and is buried about 6 ft in the ground. Poles can be as high as 100 ft if required to clear structures or terrain. They are usually spaced no more than 125 ft apart. Poles are usually owned by one utility company, which then leases space on it to other service providers.

Most utility poles are made of wood, pressure-treated with some type of preservative for protection against rot, fungi and insects. The most common tree used for telephone poles is the Southern yellow pine, but Douglas or Pacific-fir, Jack pine, and western red cedar are also common. The traditional preservative is creosote, but environmental concerns have led to the use of alternatives such as pentachlorophenol and copper naphthenate.

Wood poles have a 25 to 50 year life span, and require periodic inspection and preservative treatments. Newer poles may be made of steel, concrete, or fiberglass. Wood poles, because of their relatively low cost, remain the most common.

Electric wires strung on poles are usually single conductor, non-insulated aluminum cables. They are supported by insulators commonly mounted on a horizontal crossarm. Power is commonly transmitted using the three-phase system, requiring three wires. Subtransmission lines comprise these 3 wires, plus sometimes an overhead ground wire called a "static line" suspended above them. The overhead ground wire acts like a lightning rod preventing power surges and fires.

Distribution lines use one of two systems: grounded-y (three wires), or delta (four wires). A step-down transformer is pole-mounted near a service drop. The transformer is connected to the distribution line through protective devices called fused cutouts. In the event of an overload, the fuse melts and the device pivots open to provide a visual indication of the problem. Cutouts can also be opened manually by linemen using a long insulated rod called a hot stick.

Utility poles are grounded with a heavy bare copper wire running down the pole. At the top, the wire is attached to the metal pin supporting each insulator, and at the bottom, connected to a metal rod driven into the ground. This provides a path for leakage currents across the surface of the insulators to get to ground, preventing the current from flowing through the wooden pole which could cause a fire or shock hazard. A surge arrester (also called a lightning arrester) may also be installed for lightning protection.

Communications cables may be attached below the electric power lines, in a space designated the communications space, providing room for workers to maneuver safely while servicing the communication cables, avoiding contact with the power lines. The most common communication cables found on utility poles are copper or fiber optic cable for telephone lines and coaxial cables for cable television. The cable linking the telephone exchange to local customers is a thick cable containing hundreds of twisted pairs of subscriber lines, supported by a thin but strong metal cable. Fiber optic cables interconnecting telephone exchanges are may be present as well.

Older poles may have steel brackets that provide foot supports and handles for linemen. For security reasons, such steps are no longer allowed on new poles. Linemen use climbing spikes called gaffs to ascend wood poles. Linemen use bucket trucks for the vast majority of poles that are accessible by vehicle.

The poles at the end of a straight section of utility line, where the line ends or angles off in another direction, are called *dead-end* poles. These must carry the lateral tension of the long straight sections of wire. The power lines are attached to the pole by horizontal strain insulators. Dead-end poles require guy-wires to support them. These are steel cables attached near the top of the pole, running diagonally to an anchor buried in the ground. The guy wires have strain insulators inserted in their length, to prevent any high voltages caused by electrical faults from reaching the lower portion of the cable accessible by the public. Guy wires usually have a length of yellow plastic or wood tube reflector attached to their lower end, so that they can be seen more easily. Another means of providing support for lateral loads is a “push brace” pole, a second shorter pole that is attached to the side of the first and runs at an angle to the ground. If there is no space for a lateral support, then a stronger pole of concrete or steel may be used.

Utility poles are marked with information concerning the manufacturer, pole height, ANSI strength class, wood species, original preservative, and year manufactured. This is called branding, as it is usually burned into the surface just below "eye level" after installation. Prior to the practice of branding, many utilities would set a date nail into the pole at installation. The practice of date nails went out of general use during WWII due to war shortages; however, the practice is still used by a few utilities. These nails are considered extremely valuable to collectors, with older dates being more valuable and unique markings such as the utilities name also increasing the value. All attachments on a utility pole are the private property of the utility company, and unauthorized removal is considered a felony.

A practice in some areas is to place poles on coordinates upon a grid. The pole shown below on the right is located in a rural area of the state of Maryland. The upper two tags are specific to the subtransmission section of the pole; the first refers to the route number, the second to the specific pole along the route. The lower two tags are the "X" and "Y" coordinates along the grid. Like the coordinate plane used in geometry, X increases traveling east and Y increases traveling north. In some areas, utility pole name plates may provide valuable coordinate information – a poor man's GPS.


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