Name: _____ Date: _____

Measuring a Flagpole with a Pocket Mirror

Circle group

Climbing a flagpole to measure it is hard and not safe. But you can measure it from the ground. You need a small mirror and a tape measure. The trick uses a fact about light. When light hits a flat mirror, it bounces off at the same angle it came in.

Put the mirror flat on the ground between you and the pole. Step back until you see the top of the pole in the mirror. Now light from the top of the pole hits the mirror and bounces to your eyes. Two triangles are formed. One goes from the top of the pole to the mirror and then to the base of the pole. The other goes from your eyes to the mirror and then to your feet. The angles at the mirror match. So the triangles have the same shape. One is just bigger. They are called similar triangles.

In similar triangles, matching sides grow by the same ratio. Say your eyes are 1.5 meters high. You stand 2 meters from the mirror. The mirror is 20 meters from the pole. The mirror is 10 times as far from the pole as from you. So the pole is 10 times as tall as your eyes. It is 15 meters tall.

Measure with care. A small mistake near the mirror becomes a big mistake at the top. Surveyors and builders think this way too.

Questions

1. What two tools do you need?

_____

_____

2. Where do you put the mirror?

_____

_____

3. What fact about light makes the trick work?

_____

_____

4. What are triangles with the same shape but different sizes called?

_____

_____

5. How tall is the pole in the example?

_____

_____

6. Why can a small mistake near the mirror cause trouble?

_____

_____

Words to know

mirror: a smooth surface that shows a picture of what is in front of it
angle: the opening between two lines that meet at a point
similar: having the same shape but not always the same size
ratio: a comparison of two amounts by division
surveyors: people who measure land and distances

Talk together (every group has these)

1. Find one fact that every group read. How did your sheet say it?
2. What did your sheet tell you that you think another group's did not? Ask them.
3. What is one question about this topic that none of the sheets answered?

Name: _____ Date: _____

Measuring a Flagpole with a Pocket Mirror

Triangle group

Climbing a flagpole to measure it would be difficult and unsafe, but a small mirror and a tape measure can do the job from the ground. The trick relies on a simple fact about light. When light bounces off a flat mirror, it leaves at the same angle at which it arrived.

Place the mirror flat on the ground between you and the pole. Then step backward until you can see the very top of the pole in the mirror. At that spot, a ray of light from the top of the pole hits the mirror and bounces up to your eyes. Two triangles have formed. One runs from the top of the pole down to the mirror and along the ground to the pole's base. The other runs from your eyes down to the mirror and along the ground to your feet. Because the light meets the mirror at matching angles, the triangles have the same shape, even though one is much bigger. Mathematicians call them similar triangles.

In similar triangles, matching sides grow by the same ratio. Suppose your eyes are 1.5 meters above the ground, you stand 2 meters from the mirror, and the mirror is 20 meters from the pole. The mirror is 10 times as far from the pole as it is from you, so the pole must be 10 times as tall as your eye height. That makes it 15 meters tall.

Measure carefully, because a small mistake near the mirror grows into a large one at the top of the pole. Surveyors and builders use the same kind of reasoning to find heights and distances that they cannot reach directly.

Questions

1. What two tools do you need to measure the flagpole from the ground?

_____

_____

2. Where should the mirror be placed?

_____

_____

3. What fact about light makes the trick work?

_____

_____

4. What are triangles called when they have the same shape but different sizes?

_____

_____

5. How tall is the pole in the example?

_____

_____

6. Why does a small mistake near the mirror cause trouble?

_____

_____

Words to know

mirror: a smooth surface that shows a picture of what is in front of it
angle: the opening between two lines that meet at a point
similar: having the same shape but not always the same size
ratio: a comparison of two amounts by division
surveyors: people who measure land and distances

Talk together (every group has these)

1. Find one fact that every group read. How did your sheet say it?
2. What did your sheet tell you that you think another group's did not? Ask them.
3. What is one question about this topic that none of the sheets answered?

Name: _____ Date: _____

Measuring a Flagpole with a Pocket Mirror

Square group

Scaling a flagpole in order to measure it would be both difficult and hazardous, yet a small mirror and a tape measure are enough to determine its height without leaving the ground. The method depends on a basic principle of optics: when light strikes a flat mirror, it rebounds at exactly the same angle at which it arrived.

Lay the mirror flat on the ground somewhere between yourself and the pole, and then back away until the very top of the pole appears in its surface. At that position, a ray of light travels from the top of the pole to the mirror and reflects upward into your eyes. Two triangles have been created. One extends from the top of the pole down to the mirror and then along the ground to the base of the pole, while the other extends from your eyes down to the mirror and then along the ground to your feet. Since the light meets the mirror at matching angles, the two triangles share the same shape, although one is far larger than the other. Mathematicians describe such figures as similar triangles.

In similar triangles, corresponding sides are related by the same ratio. Imagine that your eyes are 1.5 meters above the ground, that you are standing 2 meters from the mirror, and that the mirror is 20 meters from the pole. Because the mirror is 10 times as far from the pole as it is from you, the pole must be 10 times as tall as your eye height, which makes it 15 meters high.

Careful measuring is essential, since a slight error close to the mirror is multiplied into a considerable one at the top of the pole. Surveyors and builders rely on this same style of reasoning to calculate heights and distances that they cannot reach directly.

Questions

1. Which two tools are needed to find the height of the flagpole from the ground?

_____

_____

2. Where is the mirror supposed to be placed?

_____

_____

3. Which principle of light allows the method to work?

_____

_____

4. What name do mathematicians give to figures that have the same shape but different sizes?

_____

_____

5. How tall does the pole turn out to be in the example?

_____

_____

6. Why does a slight error near the mirror become a serious problem?

_____

_____

Words to know

mirror: a smooth surface that shows a picture of what is in front of it
angle: the opening between two lines that meet at a point
similar: having the same shape but not always the same size
ratio: a comparison of two amounts by division
surveyors: people who measure land and distances

Talk together (every group has these)

1. Find one fact that every group read. How did your sheet say it?
2. What did your sheet tell you that you think another group's did not? Ask them.
3. What is one question about this topic that none of the sheets answered?

For the teacher: Measuring a Flagpole with a Pocket Mirror

Each student sheet carries a shape, not a level. The same topic and facts, written three ways.

Circle: Measuring a Flagpole with a Pocket Mirror

Easier · 229 words · Flesch-Kincaid grade 2.9

1. A small mirror and a tape measure.
2. Flat on the ground between you and the pole.
3. Light bounces off a flat mirror at the same angle it came in.
4. Similar triangles.
5. 15 meters.
6. It grows into a much bigger mistake at the top of the pole.

Triangle: Measuring a Flagpole with a Pocket Mirror

This passage · 271 words · Flesch-Kincaid grade 6.3

1. A small mirror and a tape measure.
2. Flat on the ground between you and the pole.
3. Light leaves a flat mirror at the same angle at which it arrived.
4. Similar triangles.
5. 15 meters.
6. The mistake grows into a much bigger one when it is scaled up to the height of the pole.

Square: Measuring a Flagpole with a Pocket Mirror

Harder · 299 words · Flesch-Kincaid grade 10.6

1. A small mirror and a tape measure.
2. Flat on the ground somewhere between you and the pole.
3. Light rebounds from a flat mirror at exactly the same angle at which it arrived.
4. Similar triangles.
5. 15 meters.
6. It is multiplied into a much larger error when scaled up to the height of the pole.