Name: _____ Date: _____

Finding Neptune With Pencil and Paper

Circle group

Uranus was found in 1781. Soon, astronomers began to track its path around the sun. They used the laws of gravity to guess where Uranus should be on any date. But Uranus did not follow the guesses. Some years it was a little ahead. Some years it was a little behind.

Some scientists said the planet was not to blame. They thought another planet was tugging on Uranus. That planet had to be unseen. It had to be farther out. Its gravity would change how Uranus moved.

Two mathematicians worked on the problem. One lived in France. One lived in England. They worked on their own. They had no telescope. They used pencils, paper and long calculations. They worked backward from the odd motion of Uranus. They wanted to find where a hidden planet would have to be.

In 1846, the French mathematician sent his answer to astronomers in Berlin. The astronomers aimed their telescope at that spot on the first night. In about an hour, they saw a faint point of light. It was not on their star map. It was a new planet. We call it Neptune. It was very close to where the math said it would be.

Neptune is too dim to see with just your eyes. Its discovery showed the power of careful thinking.

Questions

1. In what year was Uranus found?

_____

_____

2. What was odd about the way Uranus moved?

_____

_____

3. What did some scientists think was tugging on Uranus?

_____

_____

4. What did the two mathematicians use?

_____

_____

5. Why did the astronomers in Berlin aim their telescope at one spot?

_____

_____

6. Why is it special that Neptune was near the spot the math gave?

_____

_____

Words to know

gravity: the pull that objects have on each other
calculations: steps of math used to find an answer
mathematicians: people who work with numbers and equations
faint: weak or hard to see

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: _____

Finding Neptune With Pencil and Paper

Triangle group

Uranus was found in 1781, and astronomers soon began to track its path around the sun. They used the laws of gravity to predict where it should be on any given date. But as the years went by, Uranus kept drifting away from the predictions. It was a little ahead in some years and a little behind in others.

Some scientists decided the planet was not to blame. They suspected that the pull of another, unseen planet was tugging on Uranus. If that was true, the new planet had to be farther out, and its gravity would be changing the way Uranus moved.

Two mathematicians, one in France and one in England, each worked on the problem separately. They had no telescope. They used pencils, paper and many long calculations to work backward from the odd motion of Uranus. Their goal was to find where a hidden planet would have to be to cause it.

In 1846, the French mathematician sent his answer to astronomers in Berlin. The observers pointed their telescope at the predicted place on the very first night they received the letter. Within about an hour, they spotted a faint point of light that was not on their star map. It was a new planet, now called Neptune, and it was very close to where the math said it would be.

Neptune is too dim to see with the unaided eye. Its discovery showed how powerful careful reasoning can be.

Questions

1. In what year was Uranus found?

_____

_____

2. What was strange about the way Uranus moved?

_____

_____

3. What did some scientists suspect was tugging on Uranus?

_____

_____

4. What tools did the two mathematicians use?

_____

_____

5. Why did the astronomers in Berlin point their telescope at one spot?

_____

_____

6. Why is it impressive that the planet was found near the predicted place?

_____

_____

Words to know

predict: to say what will happen before it does
gravity: the pull that objects have on each other
calculations: steps of math used to find an answer
mathematicians: people who work with numbers and equations
faint: weak or hard to see

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: _____

Finding Neptune With Pencil and Paper

Square group

Uranus was discovered in 1781, and astronomers promptly began tracking its path around the sun. They relied on the laws of gravity to predict where the planet ought to appear on any given date. As the years passed, however, Uranus persistently strayed from those predictions, running slightly ahead of schedule in some years and slightly behind in others.

Certain scientists concluded that the planet itself was not at fault. They suspected that the gravitational pull of another, unseen planet was tugging on Uranus. If that were true, the new world had to lie farther out, and its gravity would be altering the way Uranus traveled.

Two mathematicians, one in France and one in England, tackled the problem independently of each other. Neither of them had a telescope. Armed with pencils, paper and an enormous number of lengthy calculations, they worked backward from the odd motion of Uranus. Their goal was to determine where a hidden planet would have to be in order to cause it.

In 1846, the French mathematician mailed his answer to astronomers in Berlin. On the very first night after the letter arrived, the observers pointed their telescope at the predicted location. Within about an hour they spotted a faint point of light that did not appear on their star map. It was a new planet, now called Neptune, and it was remarkably close to the place that the mathematics had indicated.

Neptune is too dim to be seen by the unaided eye, and its discovery demonstrated the extraordinary power of careful reasoning.

Questions

1. In which year was Uranus discovered?

_____

_____

2. What was strange about the way Uranus traveled?

_____

_____

3. What did certain scientists suspect was tugging on Uranus?

_____

_____

4. What tools did the two mathematicians use?

_____

_____

5. Why did the astronomers in Berlin point their telescope at one particular spot?

_____

_____

6. Why is it impressive that Neptune appeared near the predicted place?

_____

_____

Words to know

predict: to say what will happen before it does
gravity: the pull that objects have on each other
calculations: steps of math used to find an answer
mathematicians: people who work with numbers and equations
faint: weak or hard to see

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: Finding Neptune With Pencil and Paper

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

Circle: Finding Neptune With Pencil and Paper

Easier · 217 words · Flesch-Kincaid grade 3.7

1. 1781.
2. It did not follow the guesses, sometimes ahead and sometimes behind.
3. The gravity of another, unseen planet.
4. Pencils, paper and long calculations, with no telescope.
5. The mathematician's letter said where the new planet should be.
6. It shows that math and gravity could find something no one had seen.

Triangle: Finding Neptune With Pencil and Paper

This passage · 241 words · Flesch-Kincaid grade 6.9

1. 1781.
2. It kept drifting away from the predicted path, sometimes ahead and sometimes behind.
3. The gravity of another, unseen planet.
4. Pencils, paper and long calculations, with no telescope.
5. The mathematician's letter predicted where the new planet should be.
6. It shows that the math and the laws of gravity worked to find something nobody had seen.

Square: Finding Neptune With Pencil and Paper

Harder · 254 words · Flesch-Kincaid grade 9.8

1. 1781.
2. It kept straying from the predicted path, sometimes ahead and sometimes behind.
3. The gravitational pull of another, unseen planet.
4. Pencils, paper and lengthy calculations, with no telescope.
5. The mathematician's letter predicted where the new planet should be.
6. It shows that mathematics and the laws of gravity could locate something nobody had ever seen.