Retrograde Motion

Overview: Three planets, Mars, Mercury, and Venus, appear to move backward in the sky when tracked night after night. This motion is called "Retrograde Motion" and has baffled scientists for years.

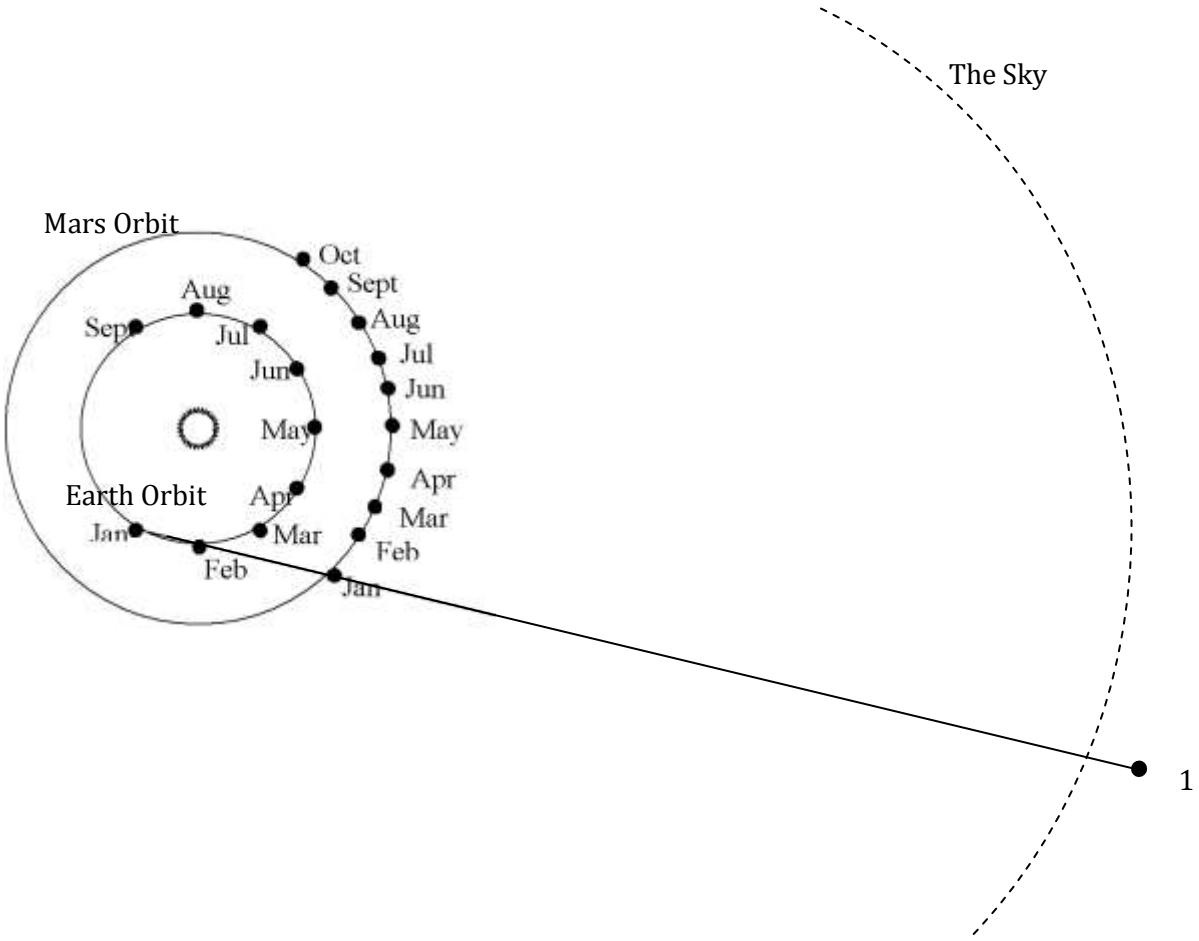
What to Learn: From a top view of the solar system, the planets appear to move around the Sun in an orderly fashion. The real chaos comes in when you place yourself on one of these planets and try to watch the path that the others take while you're orbiting the Sun. It's predictable chaos, though, with enough math and physics under your belt (like in college). Today you're just going to get a sneak peek at the wild world of orbital mechanics.

Materials

- Pencil
- Ruler

Experiment

1. Look at the diagram on the next page. The tiny center circle (without any dots) is the Sun. The inner circle is the Earth's orbit, and the other circle is the orbit of Mars. The dots show where Mars and the Earth are each month. The dashed line is the sky we'd see on Earth.
2. I've already drawn a line with my ruler connecting the two January dots. (I know it also went through February, but that's because it just happened to be there.)
3. Take your ruler and connect the two dots for February. Make sure to extend your lines a little past the sky before labeling the end of the line with a 2.
4. Do this for each month, connecting the dots starting with the inner Earth circle month to the corresponding Mars circle month. The March months should have a 3 label at the end.
5. If you find that your lines cross, make the lines a little longer and make the dots further away so you can tell which number goes with which line.
6. Now for the fun part: Play "connect the dots" with the numbered dots in the sky. Start with the 1, and carefully connect your dots in order. This line is the path that Mars will follow when you look at Mars from Earth.


The Sky
Mars Orbit
Oct
Sept
Aug
Jul
Jun
May
Apr
Mar
Feb
Jan
Aug
Sep
Jul
Jun
May
Earth Orbit
Apr
Jan
Mar
Feb
1

Reading

If you watch the moon, you'd notice that it rises in the east and sets in the west. This direction is called "prograde motion." The stars, Sun, and moon all follow the same prograde motion, meaning that they all move across the sky in the same direction.

However, at certain times of the orbit, certain planets move in "retrograde motion," the opposite way. Mars, Venus, and Mercury all have retrograde motion that have been recorded for as long as we've had something to write with. While most of the time, they spend their time in the "prograde" direction, you'll find that sometimes they stop, go backward, stop, and then go forward again, all over the course of several days to weeks.

It's like going down a racetrack on the inside curve. You pass the outside car quickly, and from your point of view, they seem to be moving backward as you pass them.

Here are videos I created that show you what this would look like if you tracked their position in the sky each night for a year or two.

Mercury and Venus Retrograde Motion

This is a video that shows the retrograde motion of Venus and Mercury over the course of several years. Venus is the dot that stays centered throughout the video (Mercury is the one that swings around rapidly), and the bright dot is the Sun. Note how sometimes the trace lines zigzag, and other times they loop. Mercury and Venus never get far from the Sun from Earth's point of view, which is why you'll only see Mercury in the early dawn or early evening.

Retrograde Motion of Mars

You've probably heard of epicycles people used to use to help explain the retrograde motion of Mars. Have you ever wondered what the fuss was all about? Here's a video that traces out the path Mars takes over the course of several years. Do you see our Moon zipping by? The planets, Sun, and Moon all travel along line called the "ecliptic," as they all are in about the same plane.

Several planets found outside our solar system (called extrasolar planets) have backward orbits. This isn't retrograde motion, just plain old backward… something we've never seen before in our search for extrasolar planets!

Mars retrogrades for 72 days every 25.6 months, Jupiter for 121 days every 13.1 months, Saturn for 138 days every 12.4 months, Uranus for 151 days every 12.15 months, and Neptune for 158 days every 12.07 months.

Exercises

1. During which of the months does Mars appear to move in retrograde?
2. Why does Mars appear to move backward?
3. Which planets have retrograde motion?

Answers to Exercises: Retrograde Motion

1. During which months does Mars move in retrograde? (Between April and July)

2. Why does Mars appear to move backward? (As the Earth passes Mars more quickly, Mars appears to slow down, stop, and reverse direction.)

3. Which planets have retrograde motion? (All planets.)