Planets in motion

September 2005

All the planets in our solar system revolve around the Sun in the same direction, clockwise when viewed from above the North Pole. This is referred to as direct motion. From our perspective on the Earth's surface, the planets travel east across the sky in relation to the background of stars. The Sun also moves eastward daily, but this is an apparent motion as it is the Earth that is actually moving, giving rise to the Sun's apparent motion against the stellar backdrop. A careful observation of the Sun's apparent path shows that over the course of an Earth year, 365.25 days, the Sun follows essentially the same 360-degree path against the stars in the background. This path is called the *ecliptic* and all planets, except for Pluto, follow a path that is within a few degrees of the ecliptic.

While direct motion is eastward, planets also travel in the opposite direction, toward the west, in what is known as *retrograde motion*. This is an apparent motion of a planet, as planets do not reverse orbital direction. From an Earth-based perspective, all planets beyond our orbit will undergo retrograde motion as we pass them by on a faster-moving Earth. Each outer planet will seem to stop direct motion, move westward in retrograde, and then return to direct eastward motion. Inner planets Mercury and Venus also retrograde, although unlike the outer planets, inner planets retrograde not as a result of a faster-orbiting Earth, but rather the inner planet's faster orbit.

FIGURE 1 **Sky chart section showing ecliptic and sky equator and location of Venus and Jupiter.**

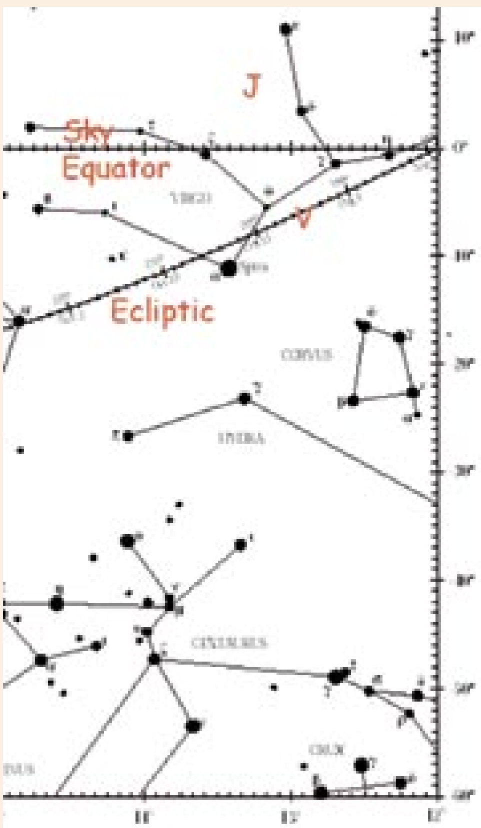
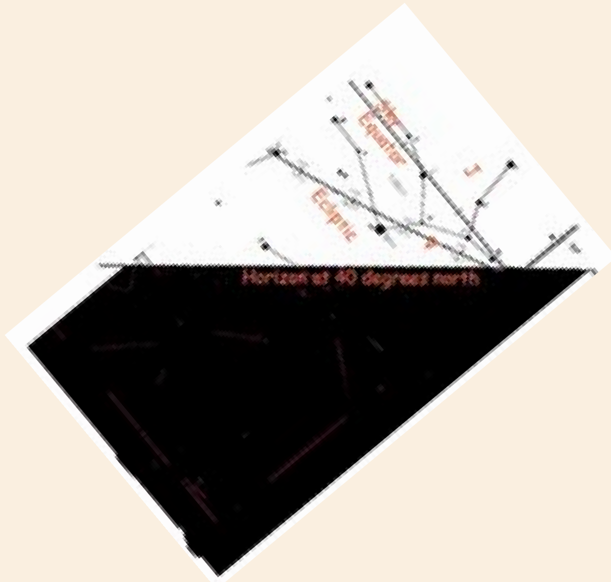


FIGURE 2 **Star chart for 40 degrees north showing the evening sky.**



The school year will begin with the two brightest planets, Venus and Jupiter, in conjunction with each other low over the western horizon at sunset. As these two planets set in the west and the sky darkens, Mars will become visible over the eastern horizon. During September, all three of these planets will be visible, but the Sun will catch up with Jupiter by the end of the month and obscure the planet. Venus, on the other hand, will appear further east of the Sun as the month progresses, making it easier to see. This motion is very obvious, and it can be plotted on either graph paper or a star chart with celestial coordinates. (See Resources for an excellent set of star charts.) This is a great opportunity to plot planetary motion because the planets can be

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Tracking the planets

Throughout the school year, data will be provided through this column for students to track the annual motion of the planets by plotting their position on either graph paper or a star chart using celestial coordinates. (See Resources for a free star chart source.)

With this data, students can use colored pencils or symbols to mark each planet location as well as to track the Sun as it appears to move along the ecliptic each day. Sun-to-planet average distance is also shown so that, for example, students could graph distance and time as a means for comparing different orbital speeds.

Planet	9/1	9/15	9/29
Mercury			
Right ascension	$9^h44^m21^s$	$11^h24^m05^s$	$12^h53^m58^s$
Declination	14°45′54″	0°43′56″	-5°11′49″
Distance	1.12719	1.36257	.40074
Venus			
Right ascension	$13^h04^m38^s$	$14^h05^m06^s$	$15^h07^m30^s$
Declination	-6°56′39″	-13°42′11″	-19°31′43″
Distance	1.14052	1.04091	0.93807
Mars			
Right ascension	$3^h01^m47^s$	$3^h18^m31^s$	$3^h26^m02^s$
Declination	14°18′52″	15°36′36″	16°23′42″
Distance	0.66263	0.59364	0.53301
Jupiter			
Right ascension	$13^h10^m01^s$	$13^h\ 20^m12^s$	$13^h31^m03^s$
Declination	-6°13′54″	-7°17′21″	-8°22′55″
Distance	6.18605	6.30643	6.39024
Saturn			
Right ascension	$8^h33^m39^s$	$8^h40^m00^s$	$8^h45^m34^s$
Declination	19°07′36″	18°45′48″	18°26′18″
Distance	9.91784	9.77356	9.59449
Uranus			
Right ascension	$22^h42^m50^s$	$22^h40^m45^s$	$22^h38^m51^s$
Declination	-9°01′41″	-9°14′02″	-9°25′12″
Distance	19.06189	19.09464	19.18413
Neptune			
Right ascension	$21^h12^m25^s$	$21^h11^m10^s$	$21^h10^m11^s$
Declination	-16° 18′ 02″	-16° 23′ 45″	-16°28′12″
Distance	29.12963	29.25106	29.41859
Pluto			
Right ascension	$17^h26^m26^s$	$17^h26^m35^s$	$17^h27^m10^s$
Declination	-15°15′00″	-15°20′09″	-15°25′34″
Distance	30.75503	30.99492	31.23442

viewed by the naked eye, and the separation between the planets and the Sun results in interesting observations.

The star chart

Planet positions are plotted on an equatorial star chart using the grid-based system that is essentially an extension of the Earth-based latitude and longitude system. Students will enjoy an application of a familiar coordinate system to something as dynamic as the sky. The SFA star chart is equatorial-based with the sky equator running the width, or length, of the chart. Along the top are calendar dates that indicate when the section of the chart below will be over the southern horizon at 8 p.m. local time. Along the bottom of the star chart are indicators for hour circles of right ascension. This type of star chart shows the ecliptic as a curved line centered on the sky equator. Dates along the ecliptic indicate when the Sun is in that location and the area around this location would represent the daytime sky. Because regular motion is eastward there is no west on a star chart such as this. A planet's eastward location is indicated by using hour circles of right ascension, or simply RA. There are 24 of these and the sky is divided in the same way the Earth is by longitude. However, there is no west so hour circles increase from 0–23 eastward. A planet is located either north or south of the sky equator and is indicated with degrees of declination, the same as how latitude is used for objects on the Earth's surface. Figure 1 shows a small section of the sky chart with Jupiter and Venus located using the celestial coordinates for September 1.

To help visualize the locations of the planets relative to the Sun and horizon at your local latitude, the star chart may be tilted and then covered with a dark piece of paper as shown in Figure 2. Place a dark piece of paper over the star chart and align the top edge with the sky equator. Then tilt the star chart until the angle between the top of the dark paper and the sky equator is the complementary angle to your latitude (90 degrees – your latitude). Adjust the dark paper so that its top edge runs through the current date on the ecliptic to represent the Sun at the horizon. Note which planets are above the horizon and their proximity to the Sun. Students can then slowly slide the star chart under the dark paper to the next day on the ecliptic, then the next day on the ecliptic, and so on. An interesting variation would be to alter the angle between the sky equator and the dark paper top edge to show the angle of the sky equator at different latitudes and how this would have an effect on the angle objects rise and set.

Visible planets

- Venus may be seen very low over the southwest horizon at sunset and will set about an hour after the Sun.
- Mars will rise in the east before midnight and will be visible above the western horizon at sunrise.
- Jupiter will be very low over the western horizon at sunset and on the evening of September 2 will be close to Venus.
- Saturn will rise about 1–2 hours before the Sun and will be visible over the eastern horizon at sunrise.

Questions for students

1. How many degree(s) does the Sun appear to move each day along the ecliptic? (approximately 1— 360 / 365.25)
2. Is Venus currently east or west of the Sun? (east—it sets after the Sun)
3. Visible planets that are to the right of the Sun are known as evening or morning planets? (morning—they "lead" the Sun across the sky, rising before the Sun)
4. What are the celestial coordinates for the Sun on the day the ecliptic crosses the sky equator during September? (approximately 0 degrees, 12 hours)
5. What is this day known as? (the September equinox)

Celestial events

September

1 Uranus at opposition
2 Venus near Jupiter
3 Pluto stationary
5 Venus near Spica
7 Waxing crescent Moon near Jupiter, Venus, and Spica
10 Waxing crescent Moon near Antares
16 Saturn near Beehive Cluster
18 Mercury at superior conjunction
22 Waning gibbous Moon near Mars and Pleiades
September equinox (SunShIP—see Resources)
28 Waning gibbous Moon near Saturn

Moon phases

	September
New Moon	9/3
First quarter	9/11
Full Moon	9/18
Last quarter	9/25

Internet resources

SFA star charts—*observe.phy.sfasu.edu*
Sun or Moon rise—*aa.usno.navy.mil*
Custom sunrise/sunset calendar—*sunrisesunset.com/custom_srss_calendar.asp*
Sun Shadow Investigation Project (SunShIP)—*sunship.currentsky.com*