

Name: \_\_\_\_\_

Section: \_\_\_\_\_

## Earth 110 – Exploration of the Solar System

### Assignment 4: Jovian Planets

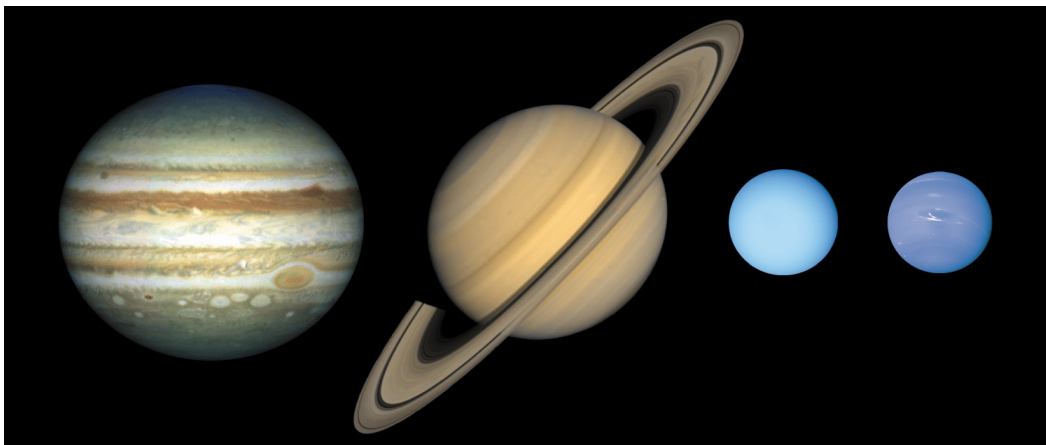
Due in class Tuesday, Feb. 23, 2016

The jovian planets have distinct characteristics that set them apart from the terrestrial planets. They are considerably less dense, but also considerably more massive. Incredibly thick atmospheres prevent spacecraft from reaching any kind of surface, if they have one, and can generate storms 2-3 times the size of Earth. They have many moons ranging in size from terrestrial planets (one of which has a thick atmosphere!) to small asteroids. Their rings, while appearing delicate or faint, are composed of particles that can be as large as mountains.

Despite these differences, comparative planetology is still relevant. Understanding terrestrial planet interiors, surfaces, and atmospheres provide the base from which to begin to understand jovian interiors and atmospheres, and the interiors, surfaces, and atmospheres of their moons. However, their distance from Earth means that space missions are more complicated, more expensive, and more risky (not to mention the amount of *time* it takes to travel out there), but necessary in order to study them.

Missions to the outer solar system mostly consist of flybys. However, Jupiter has had one orbiter (Galileo), with another on the way (Juno), and Saturn has had one orbiter/lander (Cassini-Huygens, the lander went to Titan). Uranus and Neptune were visited only by the Voyager 1 and 2 spacecraft back in 1986 and 1989, respectively, and there are no plans for future missions to these planets. While the data we have is enough to begin to understand the formation and evolution of these planets, many mysteries remain.

This assignment is based off of Chapter 11 in the textbook. As you work through this, think about how these planets compare to the terrestrial ones and how you would apply what you've already learned about solar system formation, planet interiors, surface processes, and atmospheres to the outer solar system (planets AND moons). It may seem inhospitable out there, but some jovian moons have conditions necessary for life. Should we go find it?



The jovian planets of our solar system

### Jovian Planet Interiors

*Seismology:*

Could we use seismology to study the interiors of jovian planets? Why or why not?

*Average Density:*

Calculate the average density of the jovian planets (in  $\text{kg/m}^3$ ).

<b>Planet</b>	<b>Mass (kg)</b>	<b>Radius (km)</b>	<b>Density (<math>\text{kg/m}^3</math>)</b>
Jupiter	$1.9 \times 10^{27}$	69,911	
Saturn	$5.7 \times 10^{26}$	58,232	
Uranus	$8.7 \times 10^{25}$	25,362	
Neptune	$1 \times 10^{26}$	24,622	

Compare jovian density with the density of ice (about  $1000 \text{ kg/m}^3$ ) and with air (about  $1 \text{ kg/m}^3$ ). What can you say about the interior density structure? Relate this to what you learned about jovian interiors from solar system/planet formation (Be careful about unit conversions!)

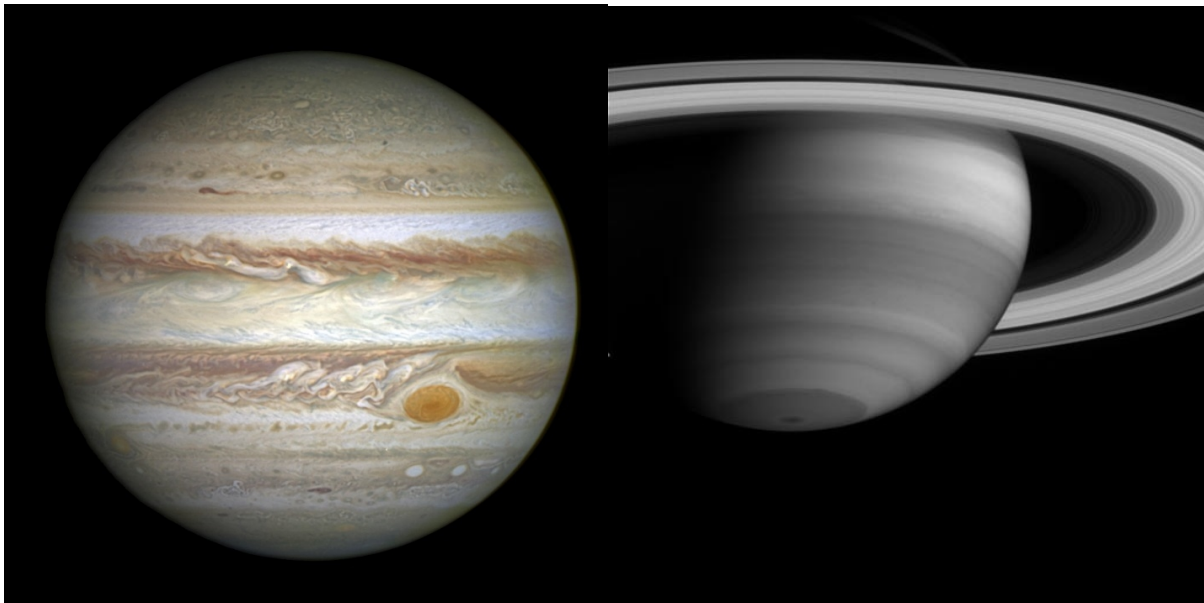
Jupiter and Saturn are composed mostly of hydrogen and helium, but Jupiter's average density is 1.9 times higher than Saturn's. In addition, Jupiter is about 3 times as massive as Saturn but its radius is only 1.2 times the radius of Saturn. Why is this? Think about overburden pressure (stacking pillows).

Uranus and Neptune are considerably smaller than Jupiter and Saturn, composed mainly of hydrogen *compounds* (like water, ammonia, and methane) instead of hydrogen and helium gas, even though their rocky cores are of similar size. Why this difference? Think about Kepler's Third Law and how the timing of certain processes during solar system formation can change planet composition.

## Jovian Atmospheres

The Coriolis effect alters the path of air in an atmosphere of a rotating planet and depends on the planet's size and rotation rate. For Earth, the Coriolis effect segments the northern and southern atmospheric circulation cells into 3 parts, resulting in 6 cells over the entire planet (see Figure 10.16). These cells govern weather patterns in the northern and southern hemispheres.

The jovian planets rotate much faster than the terrestrial planets, with a rate ranging from about 10 to 17 hours. What do you expect the strength of their Coriolis effect to be with relation to Earth's? How does this affect their atmospheric circulation cells? How would this affect weather patterns? Explain using the below images of Jupiter and Saturn and a video of Jupiter's cloud motions (<https://www.youtube.com/watch?v=1-9ULWGHFD0>).



Would you expect the jovian planets to have a magnetic field? Why or why not? Think about the factors required to generate a magnetic field. Would you expect a jovian magnetosphere to be larger or smaller than Earth's? Explain your reasoning.

### Jovian Moons

Pick a jovian moon of your choice. Which one is it? Why did you choose it? What's interesting or special about it?

Although outer moons are small and should have lost their internal heat long ago, some are still very active. This is because of *tidal heating*. Explain tidal heating. Why is Io in particular so active?

### Jovian Planet Rings

When one thinks of planetary rings, the mind always goes to Saturn. Saturn's rings span more than 270,000 km in diameter, but the rings are only a few tens of meters thick. Explain why these rings are so *flat*.

How are rings created? Are they expected to last for billions of years? Why or why not?

Explain how the below ring gap was created.

