

NAME: _____

Section Number: _____

Homework 10: Saturn, Uranus and Neptune

Due: in your section on **the week of April 14th**. Be neat and concise, show your work, and remember units. An answer without the correct units is wrong.

Suggested reading: Lecture notes 27, 28, and 29, and chapters 10.2, 7.1, and 11.1.

1. [3 Points] Suppose the material that formed Jupiter came together without any rotation so no "jovian nebula" formed and the planet today wasn't spinning. How else would the Jovian system be different? List at least THREE effects and explain each in a sentence.

Here are 5 possible effects

- 1) There would be no belts or zones in the atmosphere
- 2) There would be no magnetic field
- 3) Jupiter would not be oblate, it would be perfectly spherical

These assume the moons were not "captured"

- 4) There would be no moons, since there is no "nebula" from which they could form
- 5) There would be no rings, because there would be no moonlets that could be tidally disrupted and torn apart to form rings.

2. [2 Points] If Saturn's rings are not solid, why do they look solid when viewed through a small telescope?

Saturn's rings look solid because the angular sizes of the objects that make up the rings are smaller than the resolution of the telescope.

3. [2 Points] Describe the seasons on Uranus. Why are the Uranian seasons different from those on any other planet?

The seasons on Uranus are very extreme. Winter plunges half of the planet in complete darkness. In summer the opposite occurs with the entire hemisphere being illuminated by the sun. Only in the Spring & Fall is there a rising and setting of the sun. Because Uranus has an 81 year orbit, the hemisphere experiencing winter, is in dark for several decades.

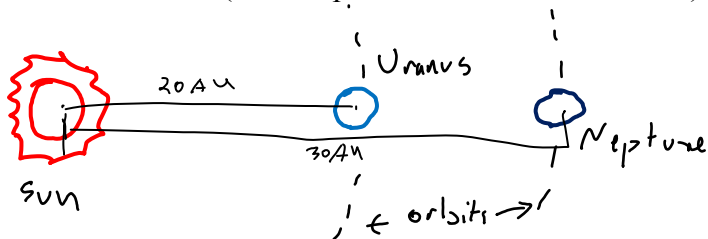
These extreme seasons come from Uranus's 98 degree axis tilt. Uranus is essentially laying on its side!

4. [3 Points] Explain why the atmosphere of Neptune has features that are like Jupiter and Saturn while the atmosphere of Uranus is essentially featureless.

Scientists are not entirely sure. This fact may be attributed to Uranus having less internal heat than the other Jovian planets. Uranus's extreme seasons, due to axis tilt & 84 yr orbit, may also play a part as recent observations show some storms as sunlight returns to the northern hemisphere.

5. Detecting Neptune:

- a. [2 Points] At what planetary configuration is the gravitational force of Neptune on Uranus at a maximum (Draw a picture or describe in words)?



The gravitational force is at a maximum when the Sun, Uranus, and Neptune are aligned in a straight line.

- b. [4 Points] For this configuration, calculate the gravitational force exerted by the sun on Uranus and by Neptune on Uranus.

Force from sun

$$F_s = \frac{GM_s M_u}{D_u^2}$$

where $G = 6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2}$ gravitational constant

$M_s = 1.99 \times 10^{30} \text{ kg}$ Mass of sun

$M_u = 8.68 \times 10^{25} \text{ kg}$ Mass of Uranus

$D_u = 20 \text{ AU} = 3 \times 10^{12} \text{ m}$ Distance of Uranus to sun

$M_N = 1.02 \times 10^{26} \text{ kg}$ Mass of Neptune

$$F_s = \frac{(6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2})(1.99 \times 10^{30} \text{ kg})(8.68 \times 10^{25} \text{ kg})}{(3 \times 10^{12} \text{ m})^2}$$

$$F_s = 1.28 \times 10^{21} \text{ N}$$

Force from Neptune

$$F_N = \frac{GM_N M_u}{d^2}$$

$d = D_N - D_u = 30 \text{ AU} - 20 \text{ AU} = 1.5 \times 10^{12} \text{ m}$ Distance between Neptune & Uranus

$$F_N = \frac{(6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2})(1.02 \times 10^{26} \text{ kg})(8.68 \times 10^{25} \text{ kg})}{(1.5 \times 10^{12} \text{ m})^2}$$

$$F_N = 2.57 \times 10^{17} \text{ N}$$

- c. [2 Points] By what fraction is the sunward gravitational pull on Uranus reduced by the pull from Neptune?

$$\text{Fraction} = \frac{\text{Force from Neptune}}{\text{Force from Sun}} = \frac{F_N}{F_s}$$

$$\text{Fraction} = 2 \times 10^{-4} = 0.02\%$$

- d. [2 Points] Based on your calculations, do you expect that Neptune has a relatively large or relatively small effect on Uranus's orbit?

Based on the fact that Neptune reduces the sunward pull by 0.02%, Neptune has a relatively small effect on Uranus's orbit. Considering that Neptune was discovered by detecting this small effect on Uranus, it makes Neptune's method of discovery all the more amazing.