Name: ______________________

Astronomy 101 Lab: Kuiper Belt Discovery

Be prepared to make calculations in today's lab. Any calculator is acceptable.

Pre-Lab Assignment: In class, we've talked a little about objects in the Kuiper belt. In this lab, you'll search for Kuiper belt objects and even one of the dwarf planets. Answer the following questions before coming to lab.

A) What direction do the planets appear to move in the sky compared the stars as they orbit the Sun?

B) What is the Kuiper belt and where is it located in the Solar System?

C) What are the requirements for an object to be classified as a planet?

D) How do astronomers go about searching for Kuiper belt objects?

Introduction: Long thought to exist as the reservoir of the short period comets of the Solar System, the Kuiper belt wasn't officially discovered until 1992. Since that time, over 1,000 Kuiper belt objects have been discovered. Astronomers believe that the Kuiper belt may contain countless objects and some suggest as many as 100,000 objects at least 100 km in diameter.

Despite the fact that the Kuiper belt lies within the Solar System, the fact that the objects being studied are so small in size means that astronomers still find it very difficult to detect these objects. It requires sensitive telescopes able to scan large regions of the sky over long periods of time to discover and determine the properties of these objects.

In this lab, you will use simulated data to locate and study several Kuiper belt objects. You'll even uncover a dwarf planet and some other objects by the time that the lab is complete.

Procedure: Answer the following questions before you continue.

1A. Describe how the brightness of an object in the Kuiper belt is related to its distance from us.

1B. Describe how the brightness of an object in the Kuiper belt is related to its physical size.

2. Why is it so difficult to detect objects in the Kuiper belt?

On your lab table, you'll find two sets of star fields, one for 2009 January 17 and 2010 January 17 and another for 2009 November 27 and 2010 November 27. **Please do not draw on the star fields!** You will follow the procedure below for each set, but it is recommended that you do each step at the same time.

Start with the chart called "Field 1: January 17, 2009." Put it down on the light table and then place the next field, "Field 1: January 17, 2010," on top of the first so that the axes and most of the points match up. Identify the five objects shown that move from one picture to the next. Record the x (horizontal) and y (vertical) coordinates from 2009 of the points on the table below. Round the coordinates to the nearest 0.1 units. ***Find the objects which move on the second set of fields as well and record their coordinates on the table on the next page.***

For each of the objects that move, measure how far they have moved from 2009 to 2010 to the nearest 0.1 units. **One unit does not correspond to one centimeter on the graph! Use the coordinates.** Record this information as "Motion (units)." In these fields, each unit corresponds to half a degree on the sky, so multiply each of your distances by 0.5 to get the angular distance that the objects move. Record this as "Motion (degrees)."

You'll find a chart labeled "Angular Motion (degrees) vs. Orbital Size (AU)" on your table. Use this chart to convert the angular motion to the size of the object's orbit around the Sun.

There is a second chart labeled "Brightness (counts)" You'll find all of the objects in your star field labeled in this chart by the x and y coordinates. Use the 2009 coordinates you recorded to determine the brightness of each of the objects.

As you discussed in Question 2, the brightness of a Kuiper belt object will depend on both its distance from us and its physical size. If you recall from our discussion of light-gathering power earlier in the semester, the brightness scales with the area of the objective or the square of the diameter. Since we have already determined the brightness, we need to take the square root of it when calculating the diameter.

We need to use a reference object to get an actual size for each object. Pluto will serve this purpose. Pluto has an average distance from the Earth of 39.5 AU and a brightness of 100,000 counts. You can use the following equation to verify that the diameter is about 2,310 km.

$$\text{diameter (km)} = 0.185 \times \text{orbital size (AU)} \times \sqrt{\text{brightness}}$$

3. **Field 1: January 17**

Object	**2009**		**2010**		**Motion (units)**	**Motion (degrees)**	**Orbital Size (AU)**	**Brightness (counts)**	**Diameter (km)**
	x	**y**	**x**	**y**					
1									
2									
3									
4									
5									

4. Which object in Field 1 has a <u>motion</u> that is significantly different than the other objects and what way is it different?

Consult the table of types of objects in the Solar System to answer Questions 5 and 8.

5. Regarding the object from the previous question, what type of object should it be? Where is it in the Solar System? Explain your answer.

6. **Field 2: November 27**

Object	2009		2010		Motion (units)	Motion (degrees)	Orbital Size (AU)	Brightness (counts)	Diameter (km)
	x	y	x	y					
1									
2									
3									
4									
5									

7. Which object in Field 2 has a motion that is significantly different than the other objects and what two ways is it different?

8. Regarding the object from the previous question, what type of object should it be? Where is it in the Solar System? Explain your answer.

9. One of the objects in your star fields is a dwarf planet. What are the requirements for an object to be considered a dwarf planet?

Consult the table of dwarf planets to answer Question 10.

10A. Which object is a dwarf planet? Give both the Star Field and the Object numbers.
10B. Use the table of dwarf planets to identify it.

Based on what you know about objects in the Kuiper belt, you should be able to put cardinal directions on your chart. Consider which way the objects moved in a year and that they have the same annual motion as the planets.

11. Is East on the left side or the right side of the field? Explain your answer. (Hint: check your pre-lab.)

In 2003, astronomers discovered one of the most distant objects in the Solar System, Sedna. Its average orbital size is 507 AU and it is estimated to have a diameter of 1000 km. It has a highly eccentric orbit, with a perihelion distance of “only” 76 AU.

Use the following equation to estimate the brightness of Sedna in your star fields. The units of brightness are “counts” in this lab.

$$\text{brightness} = [\text{diameter (km)} / 0.185 / \text{orbital size (AU)}]^2$$

12. What would be the brightness of Sedna?

13. Based on the information provided, how would you classify Sedna? Explain your answer.

Other objects have been discovered with similar orbits to that of Sedna. Some astronomers have hypothesized they are influenced by a “Planet Nine”. This object, which hasn’t been found yet, may have an average orbital size of about 600 AU and an estimated diameter of 40,000 km.

14. Calculate the brightness of Planet Nine.

Pluto, Ceres, and Eris were classified as dwarf planets in 2006, and Haumea and Makemake joined them in 2008. Although none have been added since, please check this website to look at possible additions to the group.

http://web.gps.caltech.edu/~mbrown/dps.html

15. In a paragraph of at least five sentences, describe what you think the future holds in the study of the Kuiper belt. By the year 2040, how many dwarf planets will we know? Do you think all dwarf planets should be considered planets? Should all round worlds like the Moon and Europa be considered planets?