RECON Introduction to Light Curves

Many measurements must be made indirectly – one way to measure the size of something is to use a distant point light to estimate it. Astronomers on the RECON project want us to help collect data about objects at the far-reaches of our solar system. The RECON project has students record the intensity of light coming from a distant star over a period of time. If something, such as a Trans-Neptunian Object (TNO) passes in front of the star, we will observe a change in the intensity of the light coming from that star. An **occultation** occurs when a solar-system body passes in front of a more distant object (e.g. a star or another solar system body), partially or totally hiding the more distant object and momentarily blocking its light. Each occultation can be seen only at the right time and from a limited part of the Earth. These occultations and the light intensity recordings made from them give astronomers information about TNOs, and teach us about the origin of the Solar System. RECON involves students along the entire U.S. Pacific Coast and the data collected by one single site may not seem pertinent or exciting. But when we put all the data together, we can learn a lot about those very far away objects!

Materials

LabQuest and motion sensor
Light source
Ball
Cart and track
Meter stick

Process and Procedure

1. Set up your apparatus as shown in Figure 1.
2. Turn on your light source and LabQuest. Make sure your LabQuest is measuring the intensity of the light with the light sensor. (Wave your hand in front of the light source once or twice while another student watches for changes in the intensity on the LabQuest.)
3. Move the ball at constant speed across the track while collecting light intensity and position data. Start slow, and note the change in intensity as the ball occults the light. Make multiple attempts. Watch the graph on the LabQuest change with time.
4. Try using a different ball, speed, or even light source to see how it effects the light intensity reading on the LabQuest. **Be sure to catch the cart before it hits the motion sensor.**

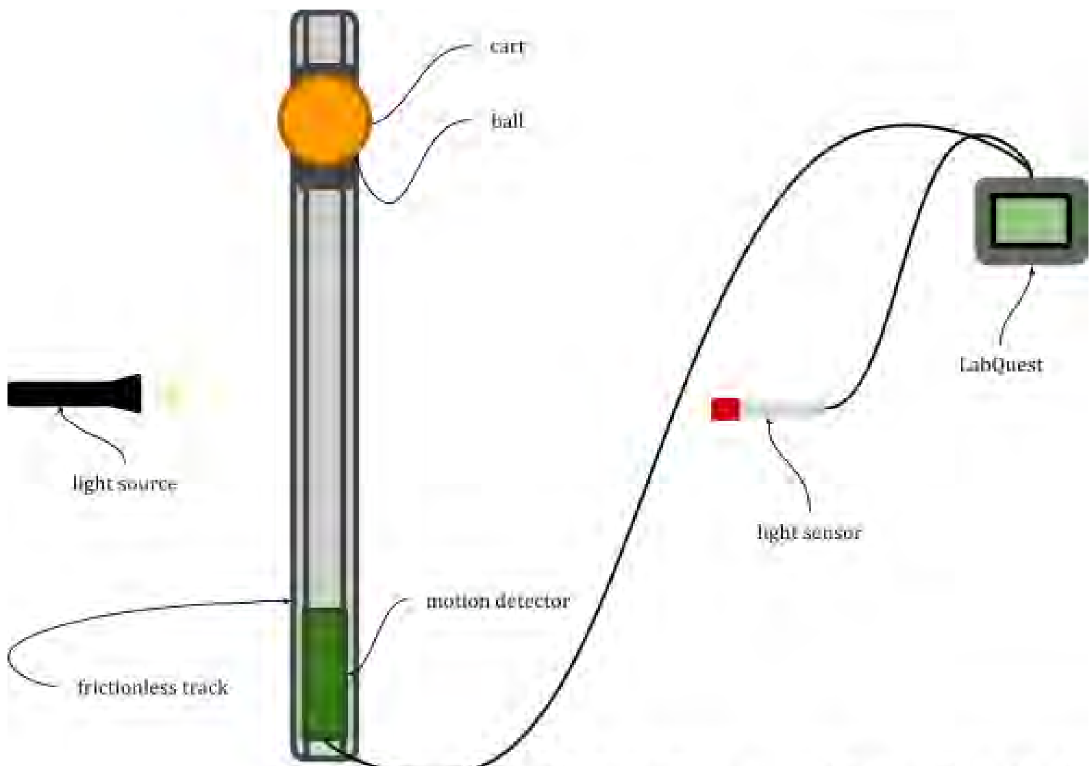
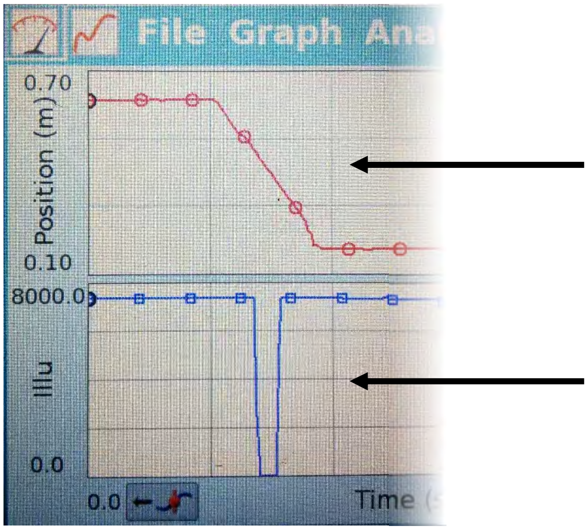


FIGURE 1 - Exploration equipment diagram (from above)

5. In your notebook, draw a sketch of an intensity graph, including the point where a ball passes in front of the light meter (the occultation). Below, you will see a screenshot of the LabQuest after data collection to help you understand which graph to sketch in your notebook.



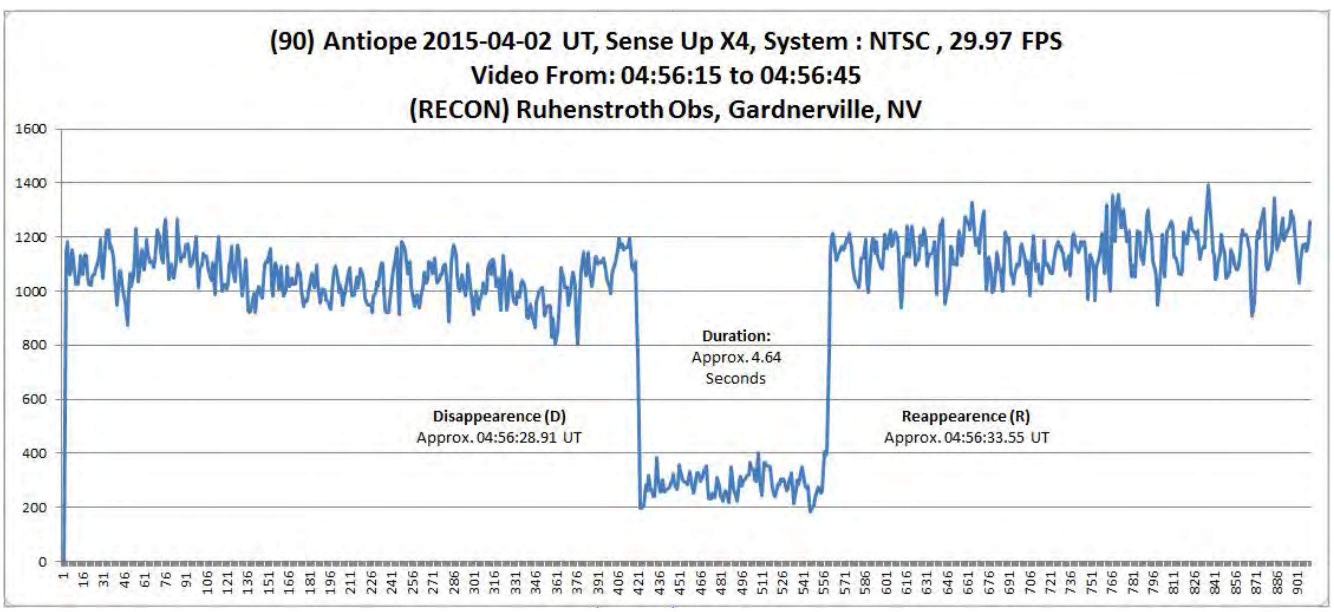
This is the position graph. Do not sketch this graph in your notebook.

This is the intensity graph.

Note the drop in intensity when the ball passed in front of the light.

FIGURE 2 – Reading the LabQuest

You have now witnessed an occultation, and have taken data to measure the change in the light intensity over time. Scientists call this graphical representation of this kind of data a “**light curve**”. When we use the speed of the object and the duration of occultation, we can determine the width of the part of the object doing the occulting. You can obtain the duration of the occultation by measuring the width of the dip of the graph. Note that the horizontal axis measures time.

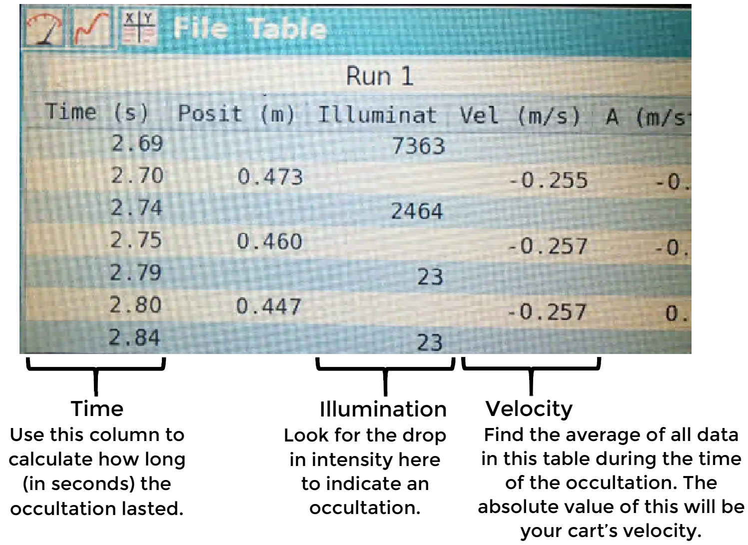


6. Astronomers can independently determine the orbit of an actual TNO by measuring the position of the object relative to background stars at different times. Combining this orbital information with our own orbit, astronomers can determine the speed of the TNO relative to Earth.

   For this activity, you can independently measure the speed of the cart on the track using the motion sensor. This device will calculate the velocity of the cart, and include that data in a table. Make sure your motion sensor is connected and operational.

7. Move the ball and cart system once more, but this time you need to record the data. To start the recording, press the green “Play” button in the bottom left corner. After the cart and ball pass in front of the light source, stop the recording with the red “Stop” button in the bottom left corner.

8. Now press the “Table” button to read the data the LabQuest has collected. Below you will see a screenshot of the LabQuest table to help you navigate the information.



File Table

Run 1

Time (s)	Posit (m)	Illuminat	Vel (m/s)	A (m/s
2.69		7363		
2.70	0.473		-0.255	-0.
2.74		2464		
2.75	0.460		-0.257	-0.
2.79		23		
2.80	0.447		-0.257	0.
2.84		23		

FIGURE 3 – Screenshot of LabQuest Table

9. Find the part of the table where the occultation occurred. This is where the value in the “Illumination” column drops significantly. Note the time the light intensity started to drop and write this number in your notebook as the “occultation start time”. Now find where the light intensity starts to increase. Note the time that this occurs, and write this number in your notebook as the “occultation end time.” Subtract the start time from the end time to calculate the duration of the occultation. Record this in your notebook.

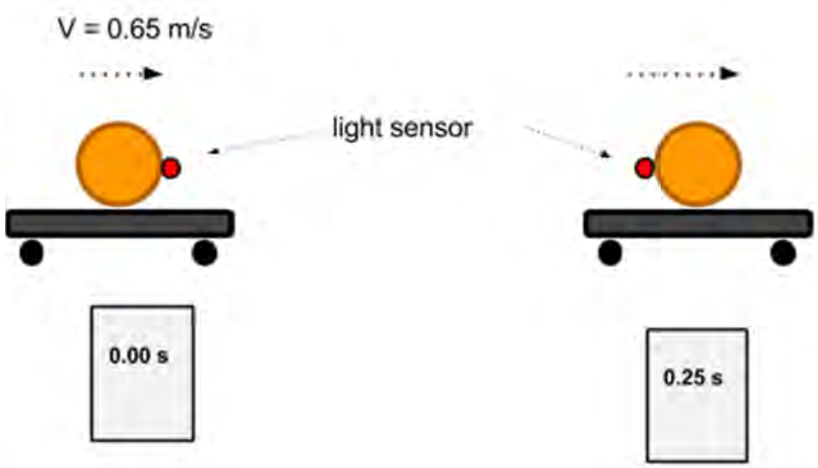
10. Starting at the occultation start time, record each velocity (in m/s) recorded until the occultation end time. Calculate the average of these data. Record in your notebook as “average velocity.”

11. You can now calculate information about the size of the ball using the light data you’ve collected. You know the speed of the ball and how much time it took the ball to pass in front of the light. Follow the equation below to calculate the size of the ball:

$$size\ of\ the\ ball = average\ velocity \times time\ the\ light\ was\ blocked$$

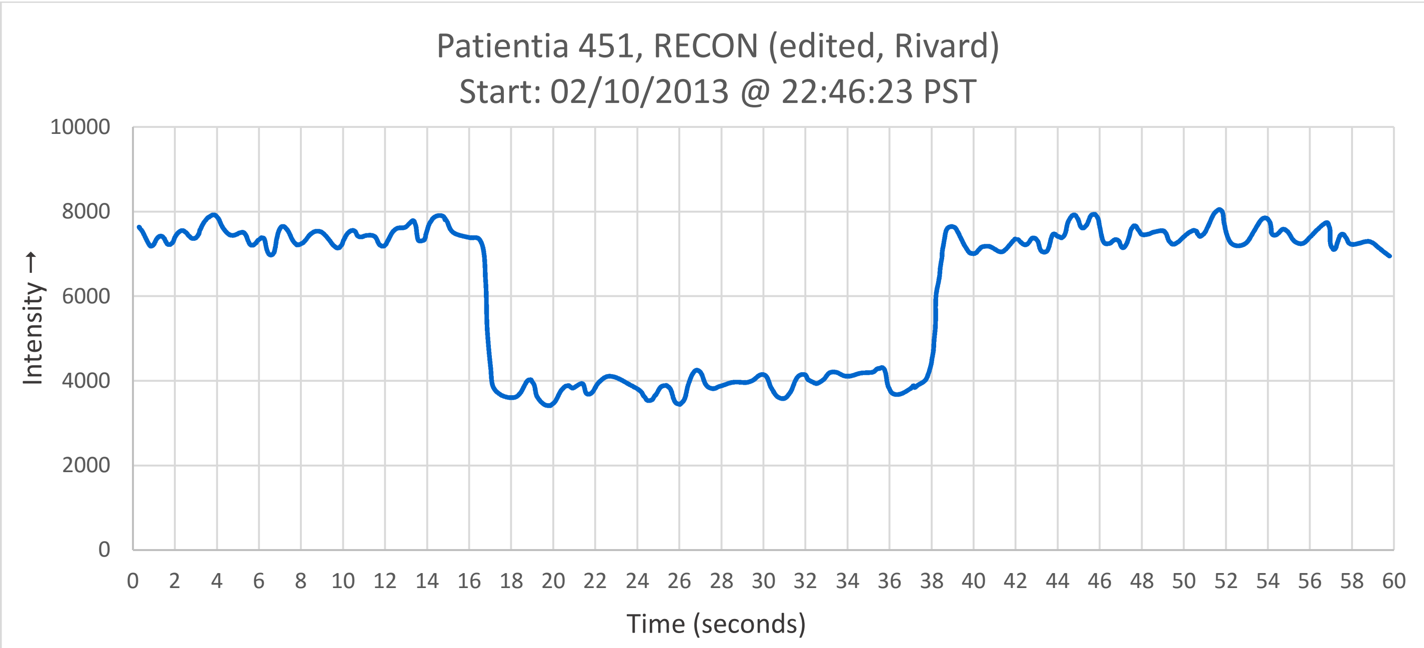
In physics, we usually see this equation like this: $\Delta x = v\Delta t$

Your answer will be in meters. How close were you to the actual size of the ball? Measure the ball with a meter stick to find out! Which portion of the ball do you need to measure to compare with your occultation answer?



Reflect and Connect

1. Look at the graph of the occultation by the object Patientia 451.
   a. How long was the occultation?
   b. If the object was traveling at 5.57 km/s, what is the length of the portion of the object that blocked the light?



2. Look at the graph of the occultation by the object Alauda 702.
   a. How long was the occultation?
   b. If the object was traveling at 13.86 km/s, what is the length of the portion of the object that blocked the light?