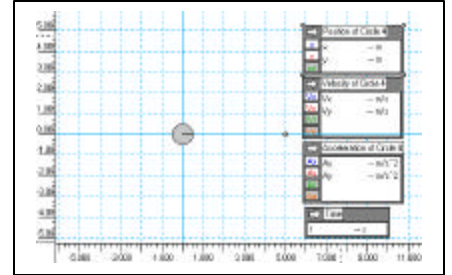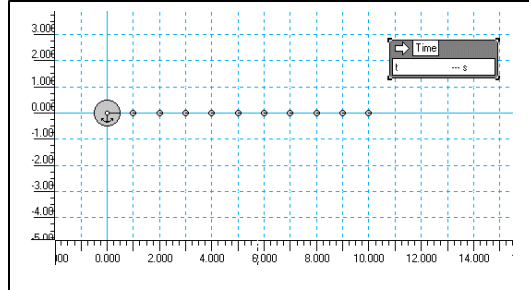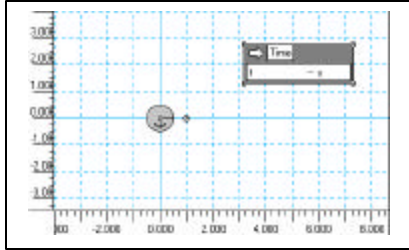# Honors Physics - Finding Kepler's 3rd and 1st Laws
12-12-03 Mr. Ward

Name _____ Per_____

Kepler's 3rd Law

You will discover Kepler's Third Law of Planetary Motion by taking data on 10 different "planets" circling a "star" using *Interactive Physics*. You will then analyze it graphically. Kepler did his analysis of Tycho Brahe's accurate data about 400 years ago.

Periods and radii of planetary orbits

1. Open "kepler1". You will see a star and a planet. (The star is made of very dense material so we can make it small and place it close to the planet.) Double click on the star and make sure it is at (0,0) meters and has a mass of one thousand kilograms. The planet should be at (1,0) meters and should have a mass of one kilogram. Fix them if needed.

2. In the lower left corner, the frame counter will read 0. Click on the right single step arrow (the one with the bar) until the planet has made one orbit. It will be back where it started on the x-axis. The orbit of this planet is circular. If you overshoot, click the left single step arrow. In the table below, RECORD the radius in meters and the period, T, in seconds. Leave the right hand column empty for now.

3. Before you can make changes to the simulation, you must first click RESET.

4. Now open "kepler2". This is the same except the circular orbit is now 2 meters. Repeat the instructions in step 2.

5. Continue running kepler3, 4, etc. until you complete kepler10. Eventually you will get to the point where single stepping takes too long. Instead, click on the right pointing run arrow to the left, the arrow without the bar. When you get near a full orbit, click the single step right arrow. If you overshoot, click the left pointing single step arrow. Leave the third column blank for now.

r, radius (m)	T, period (s)	T, period (s) for all 10
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

6. Now open "keplergraph", a Data Studio file, from the GravLab folder. (You can't open it from Interactive Physics.) Plot the radii in the x column and the periods in the y column. When finished, highlight all 10 data points and then select Fit, Power Fit. Record the Scale Factor (K) and the Power below.

Scale Factor	Power

7. Write an equation of the form $T = K \ r^{Power}$. Since your power is not a whole number (it's probably about 3/2), we need to double it. To do this, square both sides, that is, the T, K, and r^{Power}. Then solve so you have the T^2 over the r^3, equal to the scale factor squared, which is a constant, on the other side.

8. In the chart below, calculate the r^3 over T^2 for the values given.

r	r^3	T^2	T^2/r^3
1			
3			
7			
10			

9. Compare the final column values to the K squared value. What did you learn?

_____

A Puzzle

10. Open "keplerall10". You will see the star and 10 planets. Click on the single step arrow and record the periods in the right hand column of the first table above as each planet complete its orbit. What is going on and why?

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11. When you are finished, RESET. Now RUN and watch. Some interesting things happen around 5+, 30+, 90+ seconds.

Kepler's 1st Law

12. Now run "orbits" in *Interactive Physics*. Set the speed of the planet at 6 m/s and RUN it. Tracking is turned on so you can watch the orbit. You can remove the tracking after a run by clicking **Ctrl-E**. Fill in the table for each speed until you exceed escape speed. That's the speed which is high enough that the planet never completes an orbit. This happens about 20 m/s. If you lose a planet off screen, you can click on the negative magnifier and see a wider view. What on the meters indicates that the planet is not coming back? _____

_____

speed (m/s)	Shape of orbit
6	
7	
13	
14	
15	
19	
20	
21	

13. What happens to the speed of the planet in the elliptical orbits?_____

14. What happens to the speed of the planet in the circular orbit?_____

16. What shapes do orbits come in? _____