DEVIL PHYSICS
BADDEST CLASS ON CAMPUS

PhET ORBITAL MOTION LAB

1. This lab is based on one entitled 'AP Physics Gravity Lab' submitted to PhET by Michael F. Gallo (mfgallo@cps.edu), Whitney Young Magnet HS, on 1/12/12.

2. System Requirement: Macromedia Flash 9 or later.

3. Go to: https://phet.colorado.edu/en/simulation/my-solar-system and click on the play button.

Elliptical Orbits

1. (___/1) Select all of the box options (*System Centered, Show Traces, Show Grid and Tape Measure*). Set the speed index in the middle. Adjust the mass ratio between body 1 and body 2 to 100:1, set the *x-position* for body 2 to 130, and the *y-velocity* for body 2 to 140. Press *Start* and observe what happens. Now press *Reset*. Experiment with different **masses** of *body 1* until you get a nearly perfect circular orbit with very little solar perturbation (movement of body 1). Use the tape measure to confirm a circular orbit. Hit Print Screen and paste the image directly below.

   [Use the Crop tool to cut out extraneous stuff but keep the settings and the orbit visible. Remove the blue background (so as not to waste toner when you print) by clicking the image, then select the format tab, then Recolor, then Set Transparency Color, then click anywhere on the blue background. It should turn white. Do this for all pasted images ☺]

   Paste Image Here

2. (___/1) Move the speed index to the far left and use the timer function to measure the period of revolution, T. _____

3. (___/1) Re-set all of the initial conditions as you had for the previous experiment (mass ratio = 100:1, *x-position* for body 2 = 130, *y-velocity* for body 2 = 140). Experiment with different **y-velocities** of *body 2* until you get a nearly perfect circular orbit with very little solar perturbation (movement of body 1). Use the tape measure to confirm a circular orbit. [Print Screen and Paste in below, then edit as before.]
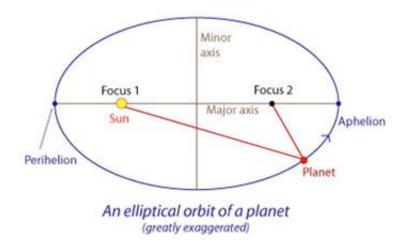
   Paste Image Here

4. (___/1) Move the speed index to the far left and use the timer function to measure the period of revolution, T. _____

5. (___/1) See what happens to the path if you increase the initial velocity by 10%? (10% greater than the circular orbit you had in step 4.) Set the speed index to the far left so your screen shot will also capture the period.

   Paste Image Here

6. (____/1) Now see what happens to the path if you decrease the initial velocity by 10%. (10% less than the circular orbit you had in step 4.) Set the speed index to the far left so your screen shot will also capture the period.

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Kepler's 3rd Law and determining big G.

An elliptical orbit of a planet
(greatly exaggerated)

7. (____/2) In the top blue window named *Select Preset*, choose *Ellipses*. Change the mass of body 1 to 200 units. Select Show Grid and click Start. Paste a screenshot of the three elliptical orbits below. For each of the 3 elliptical paths determine the period of revolution, *T*, and the semi-major axis, *a* (one half of the major axis). (Try using the Tape Measure tool) Type your results into the table below.

Paste Image Here

	T	a
Body2		
Body3		
Body4		

8. (____/2) Next, use Excel to make a graph of T^2 versus R^3 (use R = semi-major axis). Use a line of best fit (trendline) and find the slope. Use the slope result to compute the value of G (see page 263 in your textbook) and show your work below. (Show your work on the printout.) You may wonder why *G* is other than 6.67×10^{-11} (it will be way off!). You will need this result for the calculations that follow so store it in your calculator's memory.

Paste Graph Here

_____

_____

_____

_____

9. (___/3) Binary Star. Set up a 2 body system each 200 mass units at a distance of 200 units apart (body 1 x = 100, body 2 x = -100. Experiment with the initial velocities until you get the stars to follow concentric circular orbits. (Hint: the velocities will be equal but opposite.) Then measure the period of revolution. Hit Print Screen and paste the screenshot below. Use your result for *G* to calculate a theoretical value for *T* and find % error.

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_____

_____

10. (___/1) Attraction from rest. Set body 1 to 200 and body 2 to 100 mass units. Start them 400 distance units apart with initial speed zero. Click stop when they are about 100 units apart. Move the mouse over each body to get their final velocities. Paste a screenshot of your experiment.

$V_1 =$ _____.

$V_2 =$ _____.

Paste Image Here

a. (___/1) Show that momentum is conserved at the stopping point.

_____

_____

_____

_____

b. (___/2) Use your result for G in step 8 to calculate the initial potential energy $(E_P = -G\frac{M_1 M_2}{r})$. Show that mechanical energy is conserved by comparing the potential energy to the total kinetic energy at the stopping point. *They won't be exact because of G rounding, but should be equal to one significant figure.*

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_____

11. (___/3) Maximum Altitude. Set the mass of body 1 to 200 and body 2 to 0.01 units. Start body 1 at x = 80 units (pretend this is the radius of the planet), y = 0, and velocity = 0,0. Set body 2 at position 0,0 with initial velocity $v_x = -200$, $v_y = 0$ units. Use the measuring tape tool to measure the maximum altitude, h, as shown by the trace. Use your result for *G* in step 8 to calculate a theoretical value for h. Find %error.

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h measured = _____

_____

_____

_____

_____

_____

_____

_____

12. (___/2) Now do some experimenting of your own. Describe your most interesting experiment and paste in at least one screen shot showing what you did. Your own experiment should not be identical to any Presets or your classmates' experiments.

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COMMENTS / IMPROVEMENT: This lab can be improved by:

You may submit this lab electronically to Focus or by hardcopy. If submitted electronically, ensure your filename is "LastNameFirstInitialPerXLabName"