Physics Excel Lab Exercise IIa
Using a SpreadSheet to Solve a Physics Problem

Name ____ Period: ___________

Introduction: Spreadsheets are calculating devices that make it easy to carry out a series of complex calculations while keeping track of all the intermediate results. Inside the spreadsheet it is then very easy to duplicate such a series of calculations on varying data sets. Because of their simplicity, spreadsheets are very useful to physicists, and other scientists, whenever calculations need to be repeated with high reliability on small, medium, or large data sets. Spreadsheets are also very useful because they minimize recalculation time whenever the input values or data are going to be frequently changed. Spreadsheets have the advantage over calculators that the calculations are easy to program and debug, and once the calculations are properly programmed they are easily duplicated and applied to changing data and changing inputs without additional programming. In this exercise you will use a spreadsheet for calculating the path of a ball thrown vertically upward. You will then investigate the ease with which the input variables may be changed without further reprogramming.

Basics:
Each square of a spreadsheet is called a **CELL**. The location of a cell is given with a column letter(s) and a row number(s) (for example, B4, D33 and M1004 are the cell addresses). Cells can hold **Text**, **Numbers** (data), and mathematical **Formulas**.

Formulas in a cell must begin with an equal sign (=) and may contain references to cells with data values and other formulas. For example, a formula cell at location D6 might contain =2*C4, which means that cell D6 will take the number in cell C4, whether a data number or the result of a prior calculation, multiply it by 2 and then display the new result in cell D6.

A spreadsheet manual comes with detailed instructions for writing formulas. For our purposes here today we need to know operators =, +, –, *, /, and ^ (exponentiation).

Formulas (once entered correctly) can be copied into new cells to operate on fresh data by **Filling a Formula**. Click on a formula cell and highlight the column below it. Use **Edit, Fill Down**. Cell references in formulas automatically keep track of where the referenced cells sit relative to the cell with the formula. When a formula is copied into new cells, the new formulas use the data in cells at the same relative location to each new copy. These are called relative addresses.

All addresses in formulas are relative addresses unless you take specific actions to change their status. Before copying a formula, you can force the computer to refer to the same data cell by using what is known as an **Absolute Address**. Adding dollar signs ($) to a cell address forces the formula, and all its copies, to always use the same cell. For example, a formula that reads =F2*$B$6 will use the number from B6 in every copy. The F4 key is changes the address status to an absolute address.

Tracing the path of a ball thrown straight upward – This is the problem we worked on in Lab 08

Consider that you are on a cliff 50 meters high, and that you throw a ball of mass 3.0 kg upwards at a velocity of +2.0 m/s from the top of the cliff. On a piece of scratch paper calculate the following:

a) The maximum height of the ball and the time it takes to reach its maximum height
b) The time it takes the ball to hit the ground (*which is 50 m below the starting height*)
c) The velocity of the ball just before it hits the ground
d) The kinetic energy of the ball just before it hits the ground
e) The potential energy of the ball initially and at its maximum height

Now you will create a mathematical model and analyze the same problem with a spreadsheet

1. Open the spreadsheet template in Excel. (*The instructor will give you the name and location of the file with the column headings already prepared for you. You can study the uses of the* **Format** *menu on your own time.*)

2. Type your name in cell F3, your network username in cell F4, and your class period in cell F5.

3. Put
50.00 into C5 (Height of Cliff = y_0 – *height of the ball at the moment it leaves your hand*),
3.00 into C6 (Mass of Ball = m – *changing this cell allows you to test different masses*),
–9.81 into C7 (Acceleration of Gravity = g – *on Earth; on the Moon* $g_{Moon} = -1.67\ m/s^2$),
2.00 into C8 (Velocity of Ball at 0.00 s = v_0 – *as the ball leaves your hand, + is up*), and
0.10 into C9 (Time Increment – *the time between calculations, small increments give better time resolution but then a smaller total interval is covered in the cells on this page.*)

4. Into A12 put a zero, (**0**), the initial start time for the calculations (*this can be changed later if you decide you only need to know what happened from some other point in time onward*).

5. Into B12 put the formula to find the position of the ball at the time given in cell A12. The physics equation looks like $y = y_o + v_o t + ½at^2$. In our specific spreadsheet it should look like this

=$C$5+$C$8*A12+0.5*$C$7*A12^2

(Note: *Absolute addresses must be used to refer to parameters that define the problem in the table at the top.*)

6. Into C12 put the formula to find the velocity of the ball at the time given in cell A12. The physics equation looks like $v = v_o + at$. In our spreadsheet it should look like this

=$C$8+$C$7*A12

7. Into D12 enter the formula for the momentum of the ball at a given time. The physics equation is given by p = mv, which in our spreadsheet look like this

=$C$6*C12

8. Into E12 enter the formula for the kinetic energy of the ball at a given time. The physics equation is $K = \frac{1}{2}mv^2$, which in our spreadsheet look like this

=0.5*$C$6*C12^2

9. Try to complete column F, starting with cell F12, on your own. Enter the correct equation for potential energy. The physics equation looks like $U = mg(y_0 - y)$, which in your spreadsheet should look like

=________________________________

get this approved by the instructor

10. In column G, starting with cell G12, you need to at the kinetic and potential energies together to get the total energy. The physics equation is $E_t = K + U$, which in your spreadsheet should look like

=E12+F12

11. Into A13 enter the formula for the next time where we want to compute information about the ball. The equation is $t_{n+1} = t_n$ + (time increment), which in this spreadsheet will look like

=A12+$C$9

(*Fill the range A13 to A46 with copies of this equation - Highlight the range using the* ***LEFT*** *mouse button. Then from the menu bar select* **Edit/Fill Down**. Note: *this gives you a column of times from 0 to 3.40 sec.*)

12. Highlight the range B12 thru G46 and use Edit/Fill/Down to fill the columns with the equations you've just created (*programmed into the spreadsheet*). The spreadsheet will immediately calculate the position (*also known as the height*), velocity, p, K, U, and E_t of the ball at each time.

13. Take this opportunity to double check the calculations. Make sure they are in general agreement with the calculations you performed with the calculator at the beginning of the lab. This is a vital step when working with a spreadsheet model of a real situation. Make sure that the formulas you create make sense and give the correct answers. When you are satisfied that everything is correct. **Print out a copy of your spreadsheet and turn it in to the instructor**. At this time you should also save a copy of this spreadsheet to your H"\ drive.

14. Now we'll make a more detailed comparison of the values the spreadsheet gives with the answers provided by your own calculations. The general idea is to change the Time Increment to a finer time interval, like 0.001 s, and then set the initial time in A12 to a time just before the moment you need to examine in detail. You find the approximate time by using the larger time interval. Don't be afraid to experiment with the initial time. You can set it to any convenient time. Time zero is always the moment the ball leaves your hand, but the table need not contain time zero.

a) Where and when does the ball reach its max. height? ________ m ________ s
b) What is the velocity just before it hits the ground? ____________________m/s
c) How many seconds does it take the ball to hit the ground? _______________ s
d) What is the kinetic energy of the ball just before it hits the ground? ________ J

Note that although the spreadsheet only gives you answers at specific times, it also allows you to quickly do "what if" calculations on the motion of the ball. For example, let us say the initial velocity of the ball was changed to 6 m/s, and we wanted to know how high a 0.25 kg ball would travel. These minor changes in the initial conditions would require you to solve the new physics problem from scratch, if you did not have this spreadsheet. However, this spreadsheet can easily give you the right answer quickly! To see how well this works, go into cell C8 and type 6.00 in the place of 2.00 and in cell C6 type in 0.25.

What just happened to the spreadsheet? **It automatically recalculated the new positions, velocities, momenta, and kinetic and potential energies!** This feature makes spreadsheets incredibly valuable, timesaving tools. Now, using your spreadsheet model, find the answers to the following Questions:

Questions to be answered using your Spreadsheet Model

(Modify the data in the top section of the spreadsheet and the initial time, as needed, to answer the questions below.)

1. Use your calculator to find how high a 0.25 kg ball will travel if launched vertically with an initial velocity of 20.0 m/s on the Moon (g for the Moon is -1.67 m/s^2).

Maximum Height = ____________ *m*

Use your calculator to find how many seconds it takes this ball to reach its maximum height?

Time to reach maximum height = ____________ *s*

2. Look at the spreadsheet column where the total energy of the ball is calculated.

First, what do you notice about the total energy of the ball? _______________________

Make sure the initial values are: m = 0.25 kg, v_0 = 20.00 m/s, g = -1.67 m/s^2, time incr = 0.2 sec.

Set the initial time to 10.00 seconds in cell A12.

At what time does the ball appear to reach its maximum height? ________________

What maximum height does it appear to reach?______________________________

Do these estimates agree with your calculations from question 1? ________________

Why does the all go so high and keep going up for so long?

____

<u>Print your final version of this spreadsheet and turn-it-in to your instructor before the end of class.</u>