Introduction to Horizontal Motion & Spreadsheet

PHY406: A Physical Science Activity

Universiti Teknologi MARA
Fakulti Sains Gunaan

Name:_______________________________ HP: ______________________ Lab #2:

The goal of today's activity is to explore the nature of horizontal motion and to use MS Excel™ Spreadsheet for computation and generating graphs from experimental data.

At the end of the activity, students will be able to:

1. Tabulate data and perform calculations for average time and average speed using a spreadsheet.
2. Perform group measurements for time of horizontal motion.
3. Tabulate and graph a distance-time graph for the horizontal motion using a spreadsheet.
4. Compare and contrast the experimental distance-time graph with existing mathematical models.
5. Compare and explain predicted and experimental outcomes for both the pitching activity and the horizontal motion.

Background Information

Scientific research involve a string of activities that include making observations, defining the problems associated with the observation, reflecting on the problems, developing hypotheses or theories governing the observed event and testing the hypotheses and theories through experiments.

Phenomenon such as a falling tree or fruits from the tree, the formation of rainbows, the sound that thunder makes, the lightning that is observed or the color of the sky are not magical events. These events are natural events which can and had been explained by physicists. The ability to explain the mechanism of these events gives us insight into how and why things happen. In addition, it allows us to make predictions about similar events in the future to help with the well-being of our daily activities.

Nonetheless, the explanations for these events are not just done philosophically or from gut feelings. It is derived from a series of observations and hypotheses testing followed by experiments to test the hypotheses. Hypotheses begin with asking a series of learning questions to provide the researcher with a well-defined problem to investigate. In the case of fruits falling from trees, you could probably be curious about and begin asking questions such as:

- How long will it take for a durian to fall to the ground compared to a coconut falling from the same height of 10 meters?
- Will the speed remains the same throughout the fall?
- Will the durian make a different sound than the coconut when they hit the ground?
- Will the sound be fainter or louder if the fruits were to fall 15 meters?
- Will the size or mass of the fruit affect the speed of fall, the time it takes to arrive on the ground and the sound it makes upon impact?

Learning science by scientists for the past three hundred years is done through doing science (dialogue with nature) and through active discussions and debate with fellow scientists (dialogue with self, peers and experts). Hence, you will be doing science and engage with your peers in your quest of learning science and constructing science knowledge.

Learning and communicating the science knowledge involve the use of terms that scientists have developed before our time. These terms were operationally defined through observations, experiments and discussions of how objects interact with each other and the environment and how these interactions change under a variety of physical conditions. The events and observations made can be described and communicated by a variety of methods.

The most common description is by textual information either spoken or in writing. Sometimes, a picture is worth a thousand words and so an event can best be described by pictures or graphics. On the other hand, interactions are described by more than just words or pictures. Graphs and mathematical equations are very common and significant in making the description concise and elegant.

Hence, in most of your science activities and reporting, you will be utilizing all the four methods of communication. For example, in the case of the falling durian, the fall can be captured by video and then analysed by drawing graphs of position versus time and speed versus time. In fact, the speed can be correlated to the height of the fall. It has been proven that the square of the instantaneous speed of a falling object is directly proportional to durian's height of fall, h and the gravitational acceleration near the surface of the earth, g, or algebraically written as, $v^2 = 2gh$. Hence, your data analysis and conclusion from your research or investigation will require that you use all the 4 methods.

Algebraic or mathematical representations usually involve numerical analysis which means number crunching or calculating numbers from raw data you collected or when making predictions of future events. The process can be very time consuming and tedious. Fortunately, spreadsheets such as MS EXCEL™ can help reduce the processing time when we are dealing with many data points.

Activity 1 will allow you to experience using MS EXCEL™ to do repeated calculations in a short time, represent data in graphical forms and determine the best relationship involved between physical quantities involved in the analysis.

STUDENT ACTIVITIES

(adopted from Workshop Physics Activity Guide Module 1 Unit 1: Copyright ©2004 John Wiley & Sons Inc.)

INVESTIGATION 1-HOW FAST CAN YOU THROW A TENNIS BALL??

This section will get you to predict and measure how fast you can throw a tennis ball. You will be throwing a tennis ball onto a wall with a pre-determined distance. You will experience making predictions followed by taking measurements to test your predictions. You will be using both hand calculations and MS EXCEL™ spreadsheet calculations to find speeds based on measurement of times elapsed (difference in clock reading) for the ball to hit the wall and the distance travelled by the ball (distance from you to the wall).

You need to predict the outcomes before you begin any activities. Predictions can be just a guess, any guesses based on gut feeling. Other times, predictions are used to develop a scientific explanation for a phenomenon that has never been tested experimentally. These kinds of predictions are called hypothesis. Your predictions throughout this course will be between a guess if someone had provided some form of explanation or reasoning to a phenomenon or it could as well be a hypothesis if the explanation is not part of a documented theory.

Prediction 1:

a. What will be the maximum distance in meters that the ball will travel horizontally in one second? (This will be your predicted fastest speed.)

b. Give a reason or reasons for your prediction.

c. Would you consider your prediction to be a guess, a hypothesis or something in between? Explain your answer.

Activity 1:

Materials:

1 tennis ball
1 digital stopwatch
1 tape measure, 15 m or alternatively a 2 m strings marked at 1 m

1.1.0 METHOD

- This activity is best done in groups of 3 or 4.
- Find a nearby wall outside the classroom where you can comfortably throw a tennis ball without causing any disturbance to others.
- Try throwing at distances beginning from 10 m and see if you can hit the wall. If you do not, than reduce the distance. If it is hard for your group to record the time, then you are too close. So, increase your distance to a range of between 10 m to 20 m. Once you find the balance between distance to the wall and the time that can be recorded by the stopwatch, record the distance and throw the ball at least 3 times. Appoint one person to record the time. Each member of the group will make the throw. You can make this as a tournament to know who can throw the fastest.

1.1.1 DATA

Record your data in a table. An example of the table can be like the one in Table 1.1

Table 1.1: Distance to the wall and the time taken by you and your group members to throw the tennis ball to the wall

		B	C	D	E	F	G	H
2		Name	Distance m	t_1 s	t_2 s	t_3 s	<*t*>* s	<*v*>* s
3	1.							
4	2.							
5	3.							
6	4.							

* Note: The symbol <*t*> and <*v*> represents the average or the mean time and speed respectively. The gray zones are the rows and columns indicated in your spreadsheet.

1.1.2 RESULTS

Calculate the average time and the average speed by hand. Show your calculation. How good was your prediction?

1.1.3 CALCULATION USING SPREADSHEET

a. Open a new file in the MS EXCEL™ spreadsheet.
b. Key in your data beginning from line 2 and column A. In other words, write the labeling numbers in cell A2. Then just fill in the rest of your information from the TABLE 1.1 in the adjacent cells.
c. Your spreadsheet data for t_1, t_2, and t_3 for the first thrower should be located in cells D3, E3 and F3 respectively.
d. You will now calculate the average time for your throws, <*t*>.
   - In cell G3, enter the equation =(D3+E3+F3)/3 OR; =sum(D3:F3)/3.
   - Then you can just copy the content of cell G3 to cells G4 through G6.
e. Now calculate the average speed, <*v*>, by dividing the distance and the average time.
   - In cell H3, enter the equation; =C3/G3.
   - Then copy the content of this cell to the cells H4 through H6.
f. SAVE your file with a file name, *yourname-exp1-phy406-datecreated*. For example, *drjj-exp1-phy406-250710*.

g. How are the numbers you obtained by using the spreadsheet different from the numbers you obtained when you calculate by hand? If they are very different, explain why.

1.1.4 AVERAGE TIMES FOR THE WHOLE CLASS

a. **EVERYONE** should learn to use spreadsheet to perform calculations. Hence try to replicate what you did in the previous section but this time take the data obtained by everyone in the class.
b. You will need to exchange thumb drives to exchange the data. So if there are 20 students in the class, you will have a spreadsheet table that will be numbered from 1 until 20.
c. If you begin entering data in cell A2 like before, then your last data will be in cell A21. Perform your calculations for <*t*> and <*v*> for the average time and the average speed for each student.
   - In cell G23, find the average times for the whole class. What spreadsheet equation did you enter in that cell??

   - In cell H23, find the average speed for the whole class. What spreadsheet equation did you enter in that cell??

d. Organize the formatting of your spreadsheet so that the information can be communicated to everyone who views your spreadsheet.
e. How does your average time and speed differ from the average for the whole class? Explain your observation.

INVESTIGATION 2-MEASURING AND GRAPHING HORIZONTAL MOTION OF A BALL

This section will get you to predict and measure position change and speeds of objects which are moving near the surface of the earth. Motion of objects which move horizontally will be investigated separately from motion of objects moving vertically. Eventually, all motion which is the combination of both the vertical and horizontal motion can be analyzed by considering the motion along the horizontal and along the vertical directions.

Suppose you throw a smooth ball which rolls on a smooth surface for a distance of 10 meters.

Prediction 2:

a. What will happen to the distance the ball travel as time goes by? Will the ball move at the same speed, increasing speed or decreasing speed?

b. Give a reason or reasons for your prediction.

Activity 2:

Materials:

- 1 smooth surface ball
- 20 digital stopwatches or alternatively hand-phones
- 1 tape measure, 10 m or alternatively a 2 m strings marked at 1 m.

2.1.0 METHOD

- This activity is best done in groups of 20.
- Find a nearby smooth floor outside the classroom where you can comfortably roll a smooth ball without causing any disturbance to others.
- Mark the positions from the starting line the distances of 2.0 m until 10.0 m at intervals of 2.0 m. (2.0 m, 4.0 m, 6.0 m, 8.0 m, 10.0 m).
- Station at least 3 group members at each of the positions for them to take the time.
- Practice the throw a few times and try to make the ball to travel in a straight line.
- Throw the ball once for each person.
- Repeat until at least 3 group members have thrown the ball.

2.1.1 DATA

Record your data in a table. An example of the table can be like the one in Table 2.1

Table 2.1: Distance the ball travel and the time taken by you and your group members at each station

		B	C	D	E	F	G	H
2	Station	Name:	Distance m	t_1 s	t_2 s	t_3 s	<*t*>* s	<*v*>* s
3	1.		2.0					
4	2		4.0					
5	3		6.0					
6	4.		8.0					
7	5.		10.0					
8								
9		Average speed to travel 10 meters						

* Note: The symbol <*t*> represents the average or the mean time for the ball to travel to each station from the starting point. The average speed, <*v*>, is calculated only once after the ball had travelled the full 10 meters. The gray zones in Table 2.1 are the rows and columns indicated in your spreadsheet.

Repeat the table for the other 2 throwers.

2.1.2 RESULTS

Calculate, by hand, the average speed for the ball to travel the distance 10 meters for each thrower. Show your calculation here.

Thrower 1:

Thrower 2:

Thrower 3:

2.1.3 CALCULATION USING SPREADSHEET

a. Use the second spreadsheet, sheet 2 in the same file as activity 1.
b. Repeat what you did in activity 1. You can copy the table from spreadsheet Sheet 1 to the spreadsheet in Sheet 2.
c. Repeat the same table for each thrower.

How are the numbers you obtained by using the spreadsheet different from the numbers you obtained when you calculate by hand? If they are very different, explain why.

2.1.4 GRAPHING THE HORIZONTAL MOTION

a. Plot the graph by hand. The y-axis will be the distance travelled and the x-axis will be the average times. Label the physical quantity on the axis along with units. Put the sixth data point on the graph, the distance when the clock reading is zero.
b. **EVERYONE** should learn to use spreadsheet to perform calculations, copying data from one spreadsheet onto another and to plot graph of the horizontal motion. So, begin to plot the graph of distance versus time for each thrower.
c. Compare the graph that you plotted with the graphs in Figure 2.1.

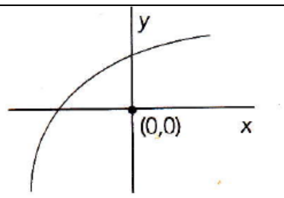	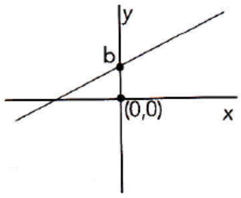	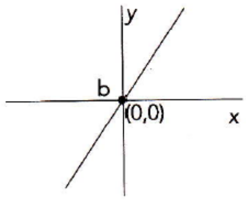
Is it just increasing as x increases but in a non-linear way?	Is it linear and in the form of y=mx+c?	Is it directly proportional and in the form of y=mx?

Figure 2.1: Three common mathematical models on relationship between two physical quantities.

d. What is the mathematical relationship between the distance travelled (position change) and the clock reading? Is the distance increasing with time, decreasing with time, linearly dependent on the clock reading or directly proportional to the clock reading? Explain.

e. How do your results compare to your earlier prediction? Is it the same or different? Explain.

f. How does each of the graphs from the three throwers compare to each other and compare to your prediction? Explain the similarities and differences.