



Universiti Teknologi MARA
Fakulti Sains Gunaan

Kinematics: Describing Non-Accelerated and Accelerated One-Dimensional Motion

PHY406: A Physical Science Activity

Name: _____

HP: _____

Lab # 4:

The goal of today's activity is to further explore and describe the nature of one-dimensional horizontal motion pictorially, textually, graphically and mathematically when an object is moving after an instantaneous push and when the object is moving with a constant continuous push.

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

1. Discuss the appropriateness of the planned investigation methods, including the physical quantities investigated and manipulated and the devices chosen to perform the investigations on observing the one-dimensional instantaneous push and the motion with a constant continuous push.
2. Draw and compare pictorial representations of motion along the x-axis after observing an object moving along the horizontal when given an instantaneous push and when experiencing a constant continuous push.
3. Describe, verbally and in writing, the motions shown by the pictorial representation.
4. Organize the collected data (perhaps by tabulating the data) and use MS EXCEL to construct graphs of position vs. time, velocity vs. time and acceleration vs. time.
5. Describe the features of the graph, the indirect quantities derived from the graph and the inferred relationship deduced from it.
6. Compare and contrast the acceleration vs. time graph, the velocity vs. time graph and the position vs. time graph for a non-accelerating and for a constant acceleration horizontal motion.

Background Information

Motion in one-dimension along the horizontal can be described pictorially, verbally (in words), graphically and mathematically. In fact, given any one of the representations, you must be able to describe the motion of the object by using any or all of the other three descriptions. Graphs and mathematical representations are often used by scientists and physicists because they are elegant, concise and compact ways for describing motion.

In lab #3, you had to visually inspect the position of the glider to measure its position as the glider was moving. How certain were you in locating its position at a particular clock reading (such as at clock reading 2 seconds) especially when the glider was moving faster and faster? Can you be certain of its position to within 5 cm? How much error did you make when you determined the speed from the position vs. time graph that you constructed?

Physics and all other sciences rely a lot on minimizing uncertainties and errors when conducting investigations. Your activities in lab #2 had introduced you to the significance of making multiple measurements and finding an average value from those multiple measurements. The activities guide you to minimize the errors and improve on the accuracy of values that you report. The smaller the uncertainty, the more accurate and trustworthiness

your result and conclusion will be. Hence, in today's activity, you will be minimizing those uncertainties by using ticker-timer and ticker tapes.

Today, in addition to causing the glider to move with an instant push like you did in lab #3, you will also make the glider move by exerting a constant continuous push produced by a fan or other appropriate tools (you need to innovate your method). In both activities, you will be using the ticker timer and ticker tape which is attached to the glider to record the positions of the glider at every instant of 0.02 seconds. On the ticker tape you will be marking off and label the glider's position. You will then use the positions indicated on the ticker tape to draw a position vs. time graph, obtain the instantaneous velocities of the glider and construct an instantaneous velocity vs. time graph.

For the case where the glider is given a constant push by a fan (or other appropriate tools) attached to it, you will be repeating the same activity as before. Additionally, you will also determine the instantaneous acceleration and then construct the acceleration vs. time graph.

The velocity vs. time graph will allow you to determine the distance travelled by an object for a certain time interval or for an entire motion while the acceleration vs. time graph will reveal the velocities of an object during the same motion.

STUDENT ACTIVITIES

INVESTIGATION 1-PICTORIAL REPRESENTATION OF A GLIDER ON A FRICTIONLESS AIR TRACK

This activity will let you locate and draw the center of a glider as it glides on a frictionless air track after being given a push. You will be connecting the glider to a ticker tape and push the glider to make it move.

Activity 1:

Materials:

Air track with gliders and its accessories (ticker timer and ticker tapes.)

Prediction 1:

Predict and draw a picture of the dots that you will observe on the ticker tape after the glider had been instantaneously pushed.

Predicted picture of dots on ticker tape

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1.1.0 METHOD

- This activity is best done in groups of 3 or 4.
- Plan and discuss your investigation procedure with your group members. Identify the variables (quantities) that you are measuring and that you keep constant. Jot down all the information that you had discussed. Discuss how you will present the data and how you will construct graphs associated with the data. You and your group members will verbally report your procedure to the lab instructor before you proceed with the investigation.
- You will need to adjust the screws underneath the air track to ensure it is leveled. Be sure to test that it is leveled before beginning your investigation.
- Do a trial run of your investigation. When everyone in the group is comfortable that your procedure is workable, proceed with the investigation.
- Remember to repeat your investigation at least once.

1.1.1 DATA

Draw the positions of the glider or affix (glue) the ticker tape on this table.

| | Picture of dots on ticker tape |
|----------|--------------------------------|
| Trial #1 | |
| Trial #2 | |

Record your data from the ticker tape in a table below and in MS EXCEL. Label the first dot you chose as dot #1 and assign the position at this dot as $x = 0$ cm. An example of the table is shown below.

Table 1.1: Distance the glider travel, its instantaneous speed and instantaneous acceleration

| | A | B | C | D | E | F |
|----|------|---------------|--|-----------------|---|---|
| 2 | Dots | Position (cm) | Distance ($\Delta x = x_{n+1} - x_n$ Eg: $\Delta x = x_2 - x_1$) (cm) | Δt s | Instantaneous speed, $v = \Delta x / \Delta t$ (cm/s) | Instantaneous acceleration, $a = \frac{\Delta v}{\Delta t} = \frac{v_{n+1} - v_n}{\Delta t}$ (cm/s ²) |
| 3 | 1 | | | 0.02 | | |
| 4 | 2 | | | 0.02 | | |
| 5 | 3 | | | 0.02 | | |
| 6 | 4 | | | 0.02 | | |
| 7 | 5 | | | 0.02 | | |
| 8 | 6 | | | 0.02 | | |
| 9 | 7 | | | 0.02 | | |
| 10 | 8 | | | 0.02 | | |
| 11 | 9 | | | 0.02 | | |
| 12 | 10 | | | 0.02 | | |
| 13 | 11 | | | 0.02 | | |

The gray zones in Table 1.1 are the rows and columns indicated in your spreadsheet.

1.1.2 RESULTS

CALCULATION USING SPREADSHEET

- Open a new file in the MS EXCEL™ spreadsheet.
- 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.
- Your spreadsheet data for Δx , v , and a for the event should be located in cells C3, E3 and F3 respectively.
- You will now calculate the Δx , v , and a respectively
 - To determine position change, Δx : In cell C3, type =B4-B3.

- To determine the instantaneous speed, v : In cell E3, type =C3/D3.
 - To determine the instantaneous acceleration, a : In cell F3, type =(E4-E3)/D3
 - Then you can just copy the content of cell C3:F3 to the lower cells C4 through F11.
- e. SAVE your file with a file name, *yourname-exp4-phy406-AS203-tues-datecreated*. For example, *drjj-exp4-phy406-AS203-tues-211013*.

GRAPHING & ANALYZING THE ONE-DIMENSIONAL HORIZONTAL MOTION

- Use the same file to construct graphs of position vs. time, velocity vs. time and acceleration vs. time.

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- Describe the graphs you constructed. Then discuss the similarities and the differences between the graphs. What relevant facts and information can you extract from the velocity and acceleration graphs respectively?

Activity 2:

In this activity, you will repeat what you did in Activity 1 but this time you will explore the one-dimensional horizontal motion where the glider is continuously pushed by a fan (or other appropriate tools) attached to it.

Materials:

Air track with gliders and its accessories (fan attachments, ticker timer and ticker tapes.)

Prediction 2:

Predict and draw a picture of the dots that you will observe on the ticker tape when the glider is continuously pushed.

| Predicted picture of dots on ticker tape |
|--|
| |

2.1.0 METHOD

- This activity is best done in groups of 3 or 4.
- Plan and discuss your investigation procedure with your group members. Identify the variables (quantities) that you are measuring and that you keep constant. Jot down, in your notebook, all the information that you had discussed. Discuss how you will present the data and how you will construct graphs associated with the data. You and your group members will verbally report your procedure to the lab instructor before you proceed with the investigation.
- You will need to adjust the screws underneath the air track to ensure it is leveled. Be sure to test that it is leveled before beginning your investigation.
- Do a trial run of your investigation. When everyone in the group is comfortable that your procedure is workable, proceed with the investigation.
- Remember to repeat your investigation at least once.

2.1.1 DATA

Draw the positions of the glider or affix (glue) the ticker tape on this table.

| | Picture of dots on ticker tape |
|----------|--------------------------------|
| Trial #1 | |
| Trial #2 | |

Record your data from the ticker tape in a table below and in MS EXCEL. Label the first dot you chose as dot #1 and assign the position at this dot as $x = 0$ cm. An example of the table is shown below.

Table 2.1: Distance the glider travel, its instantaneous speed and instantaneous acceleration

| | A | B | C | D | E | F |
|----|------|---------------|--|-----------------|---|---|
| 2 | Dots | Position (cm) | Distance ($\Delta x = x_{n+1} - x_n$ Eg: $\Delta x = x_2 - x_1$) (cm) | Δt s | Instantaneous speed, $v = \frac{\Delta x}{\Delta t}$ (cm/s) | Instantaneous acceleration, $a = \frac{\Delta v}{\Delta t} = \frac{v_{n+1} - v_n}{\Delta t}$ (cm/s ²) |
| 3 | 1 | | | 0.02 | | |
| 4 | 2 | | | 0.02 | | |
| 5 | 3 | | | 0.02 | | |
| 6 | 4 | | | 0.02 | | |
| 7 | 5 | | | 0.02 | | |
| 8 | 6 | | | 0.02 | | |
| 9 | 7 | | | 0.02 | | |
| 10 | 8 | | | 0.02 | | |
| 11 | 9 | | | 0.02 | | |
| 12 | 10 | | | 0.02 | | |
| 13 | 11 | | | 0.02 | | |

The gray zones in Table 1.1 are the rows and columns indicated in your spreadsheet.

2.1.2 RESULTS

CALCULATION USING SPREADSHEET

- Use Sheet 2 of the same file in Activity 1.
- 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.
- Your spreadsheet data for Δx , v , and a for the event should be located in cells C3, E3 and F3 respectively.
- You will now calculate the Δx , v , and a respectively
- To determine position change, Δx : In cell C3, type =B4-B3.
- To determine the instantaneous speed, v : In cell E3, type =C3/D3.
- To determine the instantaneous acceleration, a : In cell F3, type =(E4-E3)/D3
- Then you can just copy the content of cell C3:F3 to the lower cells C4 through F11.
- SAVE your file with a file name, *yourname-exp4-phy406-datecreated*. For example, *drjj-exp4-phy406-160810*.

GRAPHING & ANALYZING THE ONE-DIMENSIONAL HORIZONTAL MOTION

- Construct graphs of position vs. time, velocity vs. time and acceleration vs. time.

INVESTIGATION 2-DESCRIBING POSITION, VELOCITY AND ACCELERATION WITH WORDS AND GRAPHS

This section will allow you to describe velocity of an object using words and graph.

Activity 2: PHeT Activities

You will need to obtain the Java applets from the Colorado University by visiting the following website: <http://phet.colorado.edu/en/simulation/moving-man>

You will then be prompted to **Download** or **Run Now**. Choose the **Run Now** and you will be asked to save the following file: **moving-man_en.jnlp**. Save it to a folder on your desktop or anywhere on your hard drive. (Place it in the PHY406 folder in a subfolder called PHeT. If the subfolder has not been created, then create it.). Be sure that your laptop had already been installed with Java.

Case 1: Man moving to the left and to the right

- Explore the activities by moving the man left or right until $x = \pm 0.8$ m. You can imagine the man to be you.
- Draw the position-time, velocity-time and acceleration time graphs using the same time axis on the x axis.

- Describe how the velocity and acceleration graph changes as you move to the right and then to the left.

Case 2: Constant Velocity

- Explore the activities by setting the man to move at a constant speed, both positive and negative. (Try $v = \pm 0.5$, $v = \pm 1.0$. Stop the motion when you reach the position $x = \pm 8$ m. Make sure you go back to $x = 0$ m and reset the graphs before you begin with a new motion.
- Draw the position-time, velocity-time and acceleration time graphs using the same time axis on the x axis.

- Describe how the position vs. time and acceleration vs. time graph change. Is it similar to the graph you constructed in Activity 1 and Activity 2? Describe the similarities and differences.

