Making Motion Matter

Overview

Description

Students will be presented with graphical representations of kinematic motion and they will be asked to use these graphs to come up with other quantities that might be useful. Students will build on the ideas of position, velocity, time, and acceleration and be able to come up with and use the basic understanding of calculus to relate the quantities.

Final Product: After reviewing and addressing particular weaknesses in their understanding of kinematic motion, students will produce a story that would be explained by a graph of position vs. time. They will also produce a graph of velocity vs. time as well as acceleration vs. time for the same scenario.

Subject

Physics

Task Level

Grade 11

Objectives

Students will:

- Learn how to read a graph of position vs. time.
- Be able to describe the motion happening in the position vs. time graph.
- Infer quantities of velocity and acceleration from position vs. time graphs.
- Come up with scenarios, which would produce these graphs.

Preparation

- For each student, make a copy of the Student Notes page.

Prior Knowledge

Students should understand the fundamental concepts in algebra, trigonometry, and pre-calculus. Additionally, students should be familiar with the concepts of position, velocity, acceleration, and time.

Key Concepts and Terms

- Acceleration
- Plotting/Sketching
- Position
- Slope and “change of”
- Velocity

Time Frame

This assignment will require one or two class periods for a total time of approximately two hours. The assignment can be modified to meet the needs of different classroom schedules and student ability levels.

Instructional Plan

Getting Started

Learning Objectives

Students will:

- Review the basics of position and time in words and in graphical form.
- Relate position and time graphs to other quantities such as velocity (moving forward or backwards) and acceleration (speeding up or slowing down).

Procedure

1. Review with the students the concept of position (where an object is located), velocity (how fast an object is moving), and acceleration (how fast the object is changing speed).
2. Instruct the students to look at the position vs. time graphs in Activity 1 on their own and determine the motion of the object. Students should write down what they think using common words. For example, “The object is starting at the origin and moving to the right at a constant rate (speed).”
3. Have the student pair up and work together in groups of 2 or 3 to address any discrepancies in their answers.

Investigating

Learning Objectives

Students will:

- Address more complicated motion paths that will deal with non-zero accelerations.
- Be able to reenact simple motions described by the graphs.

Procedure

1. In their groups of 2 or 3, have the students describe in a similar manner the motion of the graphs from Activity 2. For each pair of graphs, have the students also describe the major differences.
2. Have the students working in their groups look at the graphs of Activity 3, doing the same thing as Activity 1, but also have them act out (and describe in their notes) the object being plotted in their graphs. For example, “John Doe started at the starting line (John’s desk), walked over to Jane’s desk, stayed there for a short amount of time, and finally ran back to the starting line.” If the classroom has motion sensors, students can use those to actually plot in real time what they are trying to do. This will give them some feedback of how close they are reenacting the motion.

Drawing Conclusions

Learning Objectives

Students will:

- Produce a short story that can describe the motion plotting in a relatively complicated graph.

Procedure

1. Have the students look over the graph in Activity 4. In their groups, have them use all the information they learned in the previous activities to come up with a description of the motion plotted in the graph.
2. As they are working on this, the students will be asked to come up with a story that corresponds to the complicated graph in Activity 4. As an example of what is intended (but using the first graph from Activity 3), one could devise a story about a guy who saw the love of his life and bashfully walked over to meet her. They talked for a while, and then she rejected him so he ran back home. In this story, the graph describes the motion of the guy.

Scaffolding/Instructional Support

The goal of scaffolding is to provide support to encourage student success, independence, and self-management. Instructors can use these suggestions, in part or all together, to meet diverse student needs. The more skilled the student, however, the less scaffolding that he or she will need. Some examples of scaffolding that could apply to this assignment include:

- When forming groups, sort students of various skill levels within individual groups. Ensure that everyone is engaged by drawing input from every group member when you pose questions while walking around during group activities.
- Suggest that students visit http://phet.colorado.edu/en/simulation/moving-man and play with the simulation to better visualize the relationship between position, velocity and acceleration.
- When looking at a particular graph, begin by asking the students if the object is moving or not, and if so, in what direction.
- When looking at a particular graph, ask the students if the object is moving faster or slower as time goes on.
- Suggest that the students act out what the graph is doing.
- Feel free to use motion sensors as a way to get feedback for students.

Solutions

The information below is intended to help you assess students' final work products. It may not represent all possible strategies and ideas. The accompanying scoring guide provides specific examples of ways a student might demonstrate content understanding and mastery of cross-disciplinary skills.

Necessary Elements for Activity 1:

1. Forward velocity (constant), no acceleration.
2. Forward velocity (constant), no acceleration.
3. Backwards velocity (constant), no acceleration.
4. No velocity, no acceleration.

Necessary Elements for Activity 2:

1. Increasing positive velocity, positive acceleration.
2. Decreasing positive velocity, negative acceleration.
3. Initially positive velocity (decreasing), negative constant acceleration.
4. Initially positive velocity (decreasing), negative constant acceleration.

Necessary Elements for Activity 3:

1. Starts with a positive constant velocity, then for a short amount of time, a negative acceleration happens causing the velocity to go to zero. After another short amount of time, there is another short acceleration (negative) causing the velocity to become negative after which the acceleration returns to zero and the velocity stays negative but constant.
2. Same as above includes a continuation of the constant negative velocity (going backwards) past the original starting point. There is then a positive acceleration, which causes the velocity to go to zero and continue to become positive after which the acceleration returns to zero and the velocity goes back to a constant positive value.

Necessary Elements for Activity 4:

1. This is a very complicated graph but follows everything that was discussed above. They keys are that the slope of the line is the velocity and the change of the velocity is due to the acceleration.

Key Connections

- Velocity is the change of position in a certain amount of time.
- Zero velocity is shown by sections of the graph that have constant position (local minimums and maximums).

- Acceleration is the change of velocity with respect to time.
- Zero acceleration is shown by sections of a position vs. time graph that are saddle points or places where the velocity is not changing.

Common Misconceptions

- Some students may falsely believe that zero velocity means zero acceleration.
- Some students may confuse an object having positive velocity that is decreasing with a negative velocity (positive decreasing velocity is a positive velocity with a negative acceleration).

TCCRS Cross-Disciplinary Standards Addressed

Performance Expectation	Getting Started	Investigating	Drawing Conclusions
I. Key Cognitive Skills			
A.1. Engage in scholarly inquiry and dialogue.	✓	✓	✓
A.2. Accept constructive criticism and revise personal views when valid evidence warrants.	✓	✓	✓
B.1. Consider arguments and conclusions of self and others.	✓	✓	✓
B.2. Construct well-reasoned arguments to explain phenomena, validate conjectures, or support positions.	✓	✓	✓
C.1. Analyze a situation to identify a problem to be solved.	✓	✓	✓
C.2. Develop and apply multiple strategies to solve a problem.		✓	✓
D.1. Self-monitor learning needs and seek assistance when needed.	✓	✓	✓
D.3. Strive for accuracy and precision.	✓	✓	✓
D.4. Persevere to complete and master tasks.	✓	✓	✓
E.1. Work independently.	✓		
E.2. Work collaboratively.	✓	✓	✓
F.3. Include the ideas of others and the complexities of the debate, issue, or problem.	✓	✓	✓
II. Foundational Skills			
B.1. Write clearly and coherently using standard writing conventions.	✓	✓	✓
B.2. Write in a variety of forms for various audiences and purposes.		✓	✓
C.5. Synthesize and organize information effectively.		✓	✓

TCCRS Science Standards Addressed

Performance Expectation	Getting Started	Investigating	Drawing Conclusions
I. Nature of Science: Scientific Ways of Learning and Thinking			
A.2. Use creativity and insight to recognize and describe patterns in natural phenomena.	✓	✓	✓
C.1. Collaborate on joint projects	✓	✓	✓
E.1. Use several modes of expression to describe or characterize natural patterns and phenomena. These modes of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic.		✓	✓
E.2. Use essential vocabulary of the discipline being studied.	✓	✓	✓
II. Foundation Skills: Scientific Applications of Mathematics			
C.2. Understand that a curve drawn on a defined set of axes is fully equivalent to a set of algebraic equations.	✓	✓	✓
III. Foundation Skills: Scientific Applications of Communication			
A.1. Use correct applications of writing practices in scientific communication.	✓	✓	✓
VIII. Physics			
C.1. Understand the fundamental concepts of kinematics.	✓	✓	✓

TEKS Standards Addressed

Making Motion Matter - *Texas Essential Knowledge and Skills (TEKS): Physics*
112.39.c.2. Scientific processes. The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to: 112.39.c.2.E. design and implement investigative procedures, including making observations, asking well-defined questions, formulating testable hypotheses, identifying variables, selecting appropriate equipment and technology, and evaluating numerical answers for reasonableness; 112.39.c.2.F. demonstrate the use of course apparatus, equipment, techniques, and procedures, including multimeters (current, voltage, resistance), triple beam balances, batteries, clamps, dynamics demonstration equipment, collision apparatus, data acquisition probes, discharge tubes with power supply (H, He, Ne, Ar), hand-held visual spectroscopes, hot plates, slotted and hooked lab masses, bar magnets, horseshoe magnets, plane mirrors, convex lenses, pendulum support, power supply, ring clamps, ring stands, stopwatches, trajectory apparatus, tuning forks, carbon paper, graph paper, magnetic compasses, polarized film, prisms, protractors, resistors, friction blocks, mini lamps (bulbs) and sockets, electrostatics kits, 90-degree rod clamps, metric rulers,

spring scales, knife blade switches, Celsius thermometers, meter sticks, scientific calculators, graphing technology, computers, cathode ray tubes with horseshoe magnets, ballistic carts or equivalent, resonance tubes, spools of nylon thread or string, containers of iron filings, rolls of white craft paper, copper wire, Periodic Table, electromagnetic spectrum charts, slinky springs, wave motion ropes, and laser pointers; 112.39.c.2.G. use a wide variety of additional course apparatus, equipment, techniques, materials, and procedures as appropriate such as ripple tank with wave generator, wave motion rope, micrometer, caliper, radiation monitor, computer, ballistic pendulum, electroscope, inclined plane, optics bench, optics kit, pulley with table clamp, resonance tube, ring stand screen, four inch ring, stroboscope, graduated cylinders, and ticker timer; 112.39.c.2.H. make measurements with accuracy and precision and record data using scientific notation and International System (SI) units; 112.39.c.2.J. organize and evaluate data and make inferences from data, including the use of tables, charts, and graphs; 112.39.c.2.K. communicate valid conclusions supported by the data through various methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports; and 112.39.c.2.L. express and manipulate relationships among physical variables quantitatively, including the use of graphs, charts, and equations.
112.39.c.3. Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: 112.39.c.3.A. in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student.
112.39.c.4. Science concepts. The student knows and applies the laws governing motion in a variety of situations. The student is expected to: 112.39.c.4.A. generate and interpret graphs and charts describing different types of motion, including the use of real-time technology such as motion detectors or photogates; and 112.39.c.4.B. describe and analyze motion in one dimension using equations with the concepts of distance, displacement, speed, average velocity, instantaneous velocity, and acceleration.

Making Motion Matter

Introduction

In this activity, you will be looking at and interpreting position vs. time graphs and trying to use these graphs to describe the motion of the object that is being plotted. Remember that each graph is separate from the others; different graphs do not necessarily describe the motion of the same object.

Directions

Getting Started

1. Listen and ask any questions that you might have while your instructor reviews the concepts of position, velocity, acceleration, and time.
2. Look at the position vs. time graphs in Activity 1 on your own; describe in words the motion of the object in your notebook.
3. When you have completed this, get together in groups of 2 or 3 and see if you all have the same answer. If you do not, convince your group members of why you think your answer is right, while listening to them explain why they think their answers are correct. When you are finished, you should have reached a consensus, which should be recorded in your notebooks.

Investigating

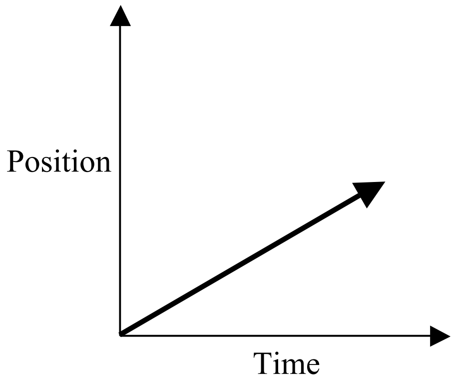
1. In your group, look at Activity 2 and describe the motion of the object in the graphs similar to what you did for Activity 1. Describe also the major differences between the pairs of graphs in this activity. Again, record your notes in your notebook.
2. Look at the graphs for Activity 3 and describe the motion. While figuring out the motion of the object, you or your group should act out the motion and record in your notebook what you and your group members did and how you acted out the motion.
3. If you have the equipment available, use a motion sensor to help recreate the graphs when you act out the motion.

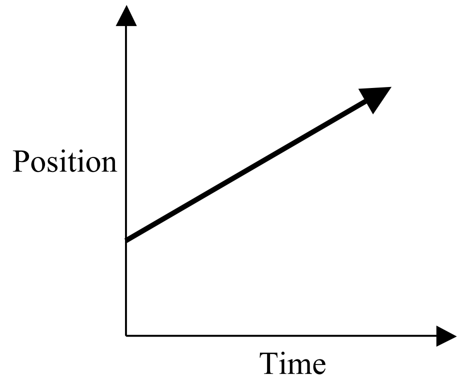
Drawing Conclusions

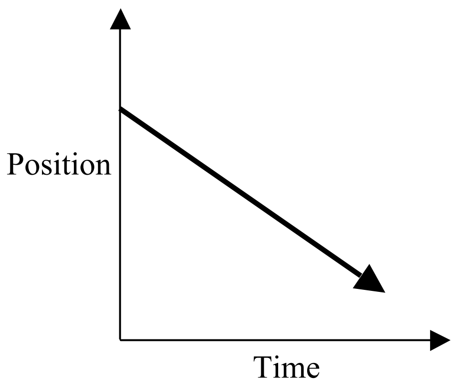
1. Look at the graph in Activity 4, and try to figure out what the motion would look like.

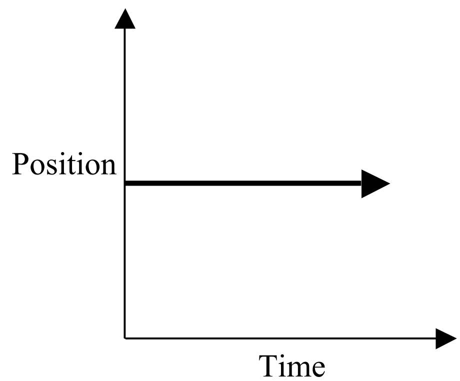
2. Once you and your group members have come up with the motion, write a story that references this motion. The main character, if tracked throughout the story, should plot the graph in Activity 4. Feel free to use your imagination, but remember that the first priority is that the motion being described is correct. Your teacher may allow you to change your graph to help fit your story.
3. Type up your story, and include a title as well as any reference graphs you might have made.

Activity 1:









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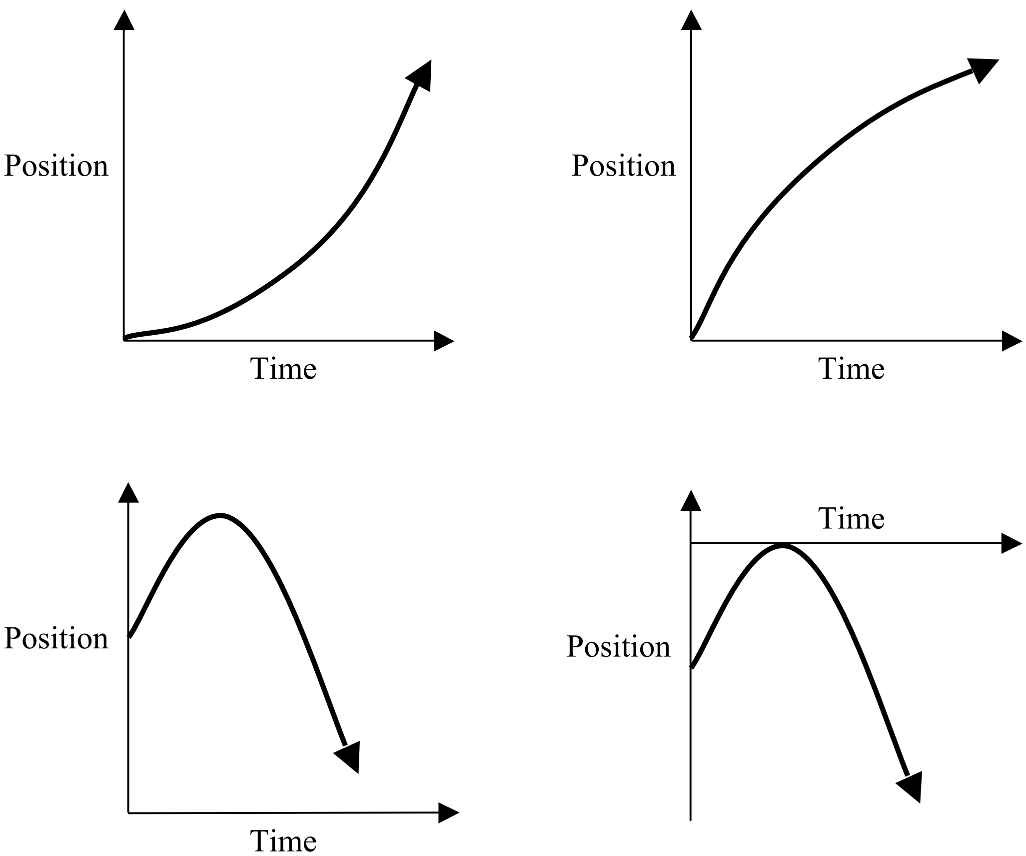

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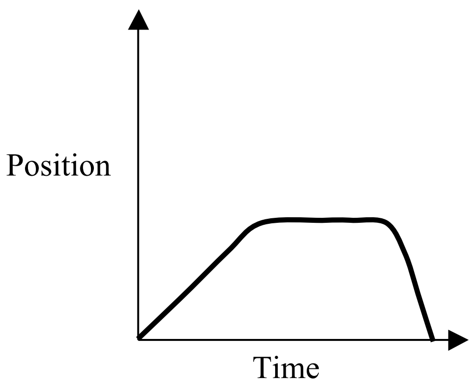

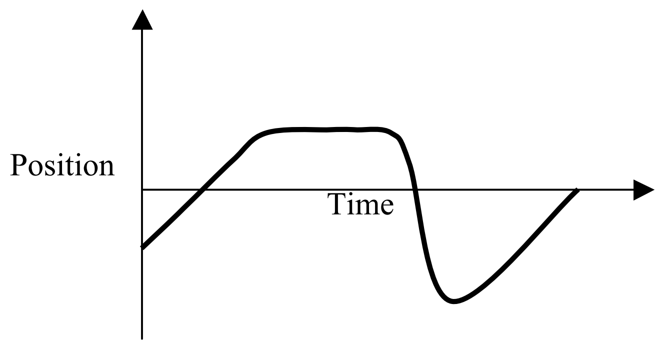

Activity 4: