Lesson Two: Graphing Complex Motion

Grade level: 6-8
Expected length of lesson: Approximately 45 to 60 minutes

Overview:

For the second day, students use their homework to evaluate position (distance), speed, acceleration and direction for complex motion. Students analyze the trip they wrote for their homework from the perspectives of distance, speed, acceleration, and direction to be used to graph the motion. Teacher asks students to draw a data set consisting of 4 graphs by the end of class: (1) distance vs. time, (2) speed vs. time, (3) acceleration vs. time, and (4) direction vs. time. Students are then expected to analyze a data set of a new situation and determine the trip events in order for complex motion. Students are in groups of 4 and roles for simulator are assigned.

Standards and/or benchmarks:

NGSS:

Disciplinary Core Ideas:

Forces and Motion

- MS-PS2-2:
  - All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

Cross-Cutting Concepts:

Scale, Proportion, and Quantity

- MS-PS3-1, MS-PS3-4:
  - Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Science and Engineering Practices:

Planning and Carrying Out Investigations

- MS-PS3-4:
  - Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

Analyzing and Interpreting Data

- MS-PS3-1:
  - Construct and interpret graphical displays of data to identify linear and nonlinear relationships.

Iowa Core:

- S.6–8.PS.3
  - The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.

Learning Goals:
Students will understand:

- Graphs depicting motion are related: (1) distance vs. time, (2) speed vs. time, (3) acceleration vs. time, and (4) direction vs. time.
- The relation of variables to time graphically.
- Graphs depicting complex motion are more complex.
- Multiple graphs are used to depict complex motion.

Learning Performances:
Students will be able to:

- Write their trip from the perspective of (1) distance, (2) speed, (3) acceleration, and (4) direction.
- Use the write up their trip from each perspective to generate a graph for each (a data set).
- Find missing events of the trip in one graph that are represented in another graph.
- Analyze a new data set to determine the motion.

Materials:

- Completed homework assignment
- Homework teacher notes
- Graph paper
- Project data set

Safety:
NA

Critical Thinking Question:
What story are the graphs telling us?

Student Ideas:
Allow student to write the stories in whatever way makes the most sense to them (paragraph, bullets, numbered list, tabular, etc.).

Main Lesson:

1. Instruct students to take out their homework assignments.
    a. If students' assignments are incomplete or less detailed, provide additional help in the next steps.
    b. If students did not complete the homework, pair them with an appropriate student who has finished the assignment.
2. Ask students where they went and how many drew maps to help them.
    a. If students have similarities on the type of trip they wrote about, grouping may be used for the next steps to allow students to help each other.
3. Instruct students to identify their starting and ending points on a new piece of paper.
4. Instruct students to write their trip from 4 different perspectives:
    a. distance from the starting point
    b. speed

    c. acceleration
    d. direction from the starting point
5. Provide instructions for writing each perspective from the starting point to the ending point.
    a. Chunk the instructions for each perspective.
    b. Consider how students organize the information (table format, bullets, or numbering the steps).
    c. Either use an example or one of the students' trips to model how to write the trip from each perspective. An example is provided in the teacher notes accompanying the homework.
    d. Monitor while students are writing their trips from each perspective to ensure that all the necessary details are included.
6. Explain to students how to make each graph after the story is written from each perspective.
    a. As a whole class, ask students to determine the variables in each perspective. They need to identify time as one variable in each.
    b. As a whole class, ask students to identify where each variable goes on the graph. Ask them to explain their thinking. Students may not use the terms dependent and independent variable, but they should be able to reason that time goes on the bottom from instruction the day before.
    c. Chunk the instructions and model how to generate a graph for each perspective. Use an example or one of the students' trips.
    d. Emphasize the shape over exact values at this time.
    e. Monitor while students graph their trip from each perspective.
7. Pair students to review each other's work.
    a. Have the students compare the *originally* written trip to the graphs. It is not necessary to read the trip from each perspective.
    b. Allow students to change and improve their graphs.
8. After students are satisfied with their graphs, have a short discussion.
    a. Ask students if the graphs look how they expected them to.
    b. Ask students if there are any parts missing from the trip in one of the graphs (a change in direction is not seen in the other graphs, etc.).
    c. Ask students if all the graphs are necessary. It may help to ask if it is easy to determine the acceleration in the distance graph.
9. Have students turn in their paperwork (the homework, the four perspectives, and graphs).
10. While handing out the activity data set (a new set of graphs like the ones the students just generated), explain to the students they need to figure out the "trip" this time.
    a. Instruct students to determine three parts:
        1. What is happening?
            a. Speeding up or positive acceleration
            b. Slowing down or negative acceleration
            c. Constant speed or constant acceleration
            d. Stopping (constant position or distance)
            e. Turning left or right (changing direction where right is positive and left is negative).

2. How long it takes in seconds. This needs to include the increment (e.g. for 20 seconds) and the total time when it starts and stops (e.g. at 80 seconds until 100 seconds).
3. The value of the motion
    a. If the speed is constant, what that speed is.

b. Model how to generate a table for the information using an example.

11. Explain to students that the table should be their best work because they are going to drive this trip on a simulator the next day.
    a. Describe the contest to them.
        1. The trip they write from the graphs is going to be driven on the simulator.
        2. Graphs from the simulator are going to be generated and they are going to compare them to the ones they were just handed.
        3. The winning group will be chosen by the students.
            a. The winner will be the group with the graphs that are closest to the originals.
            b. Get the students thinking about how they will pick the winner; what criteria will they use.
12. Select groups of 3 or 4 depending upon the number of students.
    a. Assign roles to the members of the groups. Depending upon the class, groups may assign roles themselves.
    b. Roles include
        1. Driver - Student driving the simulation.
        2. Manager - Student who determines the final driving trip and writes up the instructions to follow.
        3. Coach - Student who gives explicit instructions to the driver of what to do at each step of the driving simulation.
        4. Timer - Student who watches the on-screen timer to signal when the next step will occur.
    c. Emphasize the need to be collaborative for the best result.

Differentiation:

- Advanced learners can make a more complex trip and do not provide pre-labeled graphs or tables. Ensure they have used one of each: deceleration, complete stop, acceleration, constant speed, and direction.
- Special needs students can make a scenario with 3 events and should be given graphs with axes pre-labeled.
- For ELL students, adjust the requirements for more visual learning. Stress the terms distance, speed, acceleration, and direction.

Assessment:

- While monitoring the perspective writing and graphing ask individuals or groups probing questions.
- Collect the homework, perspectives, and graphs.