MiSP MOTION UNIT
Teacher Guide, L1 - L3

Introduction

This weeklong unit can be implemented in a variety of places in a Science 8 curriculum. Students should be familiar with distance and time measurement.

> **Standards**
>
> **ILST Core Curriculum — Major Understandings:**
> Standard 4 Physical Setting: 5.1a, 5.1b

Lesson Objectives: After completing this unit, students will be able to:

- Determine the formula for calculating speed
- Calculate the speed of an object, given the time and distance traveled
- Accurately label and number the axes on a line graph
- Graph the speed of an object
- Interpret a line graph
- Gather information based on the slope of the line.

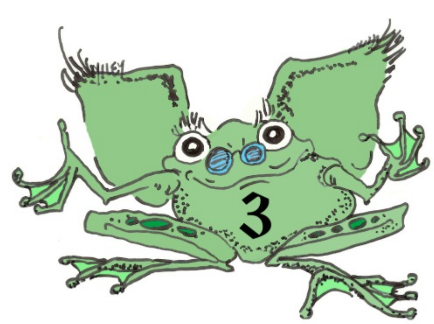
Day 1 — Motion

Hold up a ball in the front of the room. Tell the students to close their eyes. Move the ball to the side of the room. Ask students, "Since you didn't see anything, how do you know the ball moved?" Allow them to discuss possible answers to this question. Students should come to the conclusion that they know the ball has moved because its position has changed. Motion is a change in position relative to some fixed object or place. We can describe the motion of an object by knowing its position, direction, and speed.

Place a toy car on the front lab table and push it across the table. Ask students, "If we want to know how fast this car is moving, what information do we need?" Give students time to discuss possible answers. Students should come to the conclusion that in order to determine how fast the car is moving, they must know the distance the car traveled and how long it took for the car to get there (time).

Give students the following formula:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$



Hand out Worksheet #1 (“Cars”). Students will complete the review section at the top. Then they will complete the data table by calculating the speed of three different cars. Each car is a character in the movie *Cars*.

Have students complete the review questions that follow the data table. Students will calculate the speed of other objects.

Conclusion Question: What information is needed to calculate the speed of an object? What are the appropriate units for speed?

Day 2 — Motion

Students will then set up their graph. At this point, you may want to review the terms *MIX* and *DRY*.

MIX = manipulated, independent, *x*-axis
DRY = dependent, responding, *y*-axis

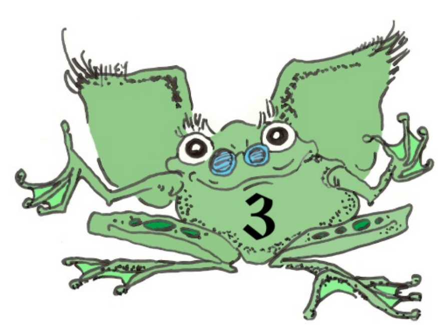
Students should follow the graphing directions on the handout to ensure that they properly set up their graph. Directions are different for each level.

<u>Analysis Level 1:</u>

1. Students will analyze each of the lines on the graph. For each car, they will choose two data points and answer the following questions:
    a. What is the difference in distance between the two points?
    b. What is the difference in time between the two points?
    c. Divide the distance by the time.
    d. What does this value represent?

2. Students will also answer the following summary questions:
    Which car is traveling the fastest?
    What do you notice about the steepness of this line?

3. Discuss with students that all three cars are traveling at a constant speed. This is why all of the lines are straight. Tell students that a change in speed or direction is called <u>acceleration</u>. Ask students to predict what the line would look like if Fillmore’s speed increased. Students will draw that line on the graph. Ask them to predict what the line would look like if Fillmore’s speed decreased. Students will then draw that line on the graph.



4. Conclusion Question: The line representing the car traveling at the fastest speed has the ____________________ (greatest steepness, least steepness). The line representing the car traveling at the slowest speed has the ______________________ (greatest steepness, least steepness).

<u>Analysis Level 2:</u>

1. Students will analyze each of the lines on the graph.
   Which car is traveling the fastest?
   What do you notice about the steepness of this line?

2. Students will follow directions to calculate the slope of each of the lines. Ask students to think about the unit rate of change for Fillmore. Fillmore's
   speed is 1 km/min, but what does that mean? For every minute that passes,
   Fillmore travels 1 kilometer. Students should now be able to explain the unit rate of change for Luigi and Lightning McQueen.

   At this point, students should realize that in order to end up on Fillmore's line, you will always need to move your pencil 10 units vertical, or 1 box up, and 10 units horizontal, or 4 boxes right. Tell students that this represents the slope, or incline, of the line. Instead of counting boxes and units, we can use a formula to calculate the slope of the line. The slope of the line can be calculated by dividing the change in *y* over the change in *x*.

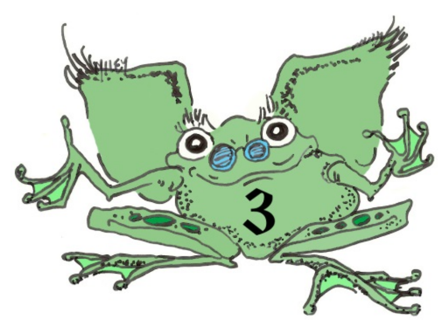
   $$\text{Slope of a line} = \frac{\Delta y}{\Delta x} \quad \text{or} \quad \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

   Tell students that the Δ symbol represents "change in."
   In order to find the "change in," you need to choose two different ordered pairs for Fillmore's line.

   Example: (10, 10) and (20, 20) are two ordered pairs for Fillmore's line.
   (x_1, y_1) (x_2, y_2)

   $$\text{Slope of Fillmore's line} = \frac{(y_2 - y_1)}{(x_2 - x_1)} = \frac{(20 - 10)}{(20 - 10)} = \frac{10}{10} = 1$$

   Ask students to think about what else the slope represents. Since we are dividing *y* (or distance) by *x* (or time), the slope also represents the speed for Fillmore. Therefore, Fillmore's speed is 1 km/min.



3. Students now have enough information to calculate the slope of Luigi's line and the slope of Lightning McQueen's line. For Lightning McQueen's line, students are given the coordinates to calculate the slope. For Luigi's line, students are asked to pick their own coordinates to calculate the slope.

4. Discuss with students that all three cars are traveling at a constant speed. This is why all of the lines are straight. Tell students that a change in speed or direction is called <u>acceleration</u>. Ask them to predict what the line would look like if Fillmore's speed increased. Students will draw the line on a graph. Ask them to predict what the line would look like if Fillmore's speed decreased. Students will then draw that line on the graph.

<u>Analysis Level 3:</u>

1. Students will use the table for each car to graph the relationship between time and distance. This will be a linear relationship. Tell students that this means all of the lines will be straight. Since this is a Level 3 lesson, students should be able to recall the steps needed to create an accurate line graph.

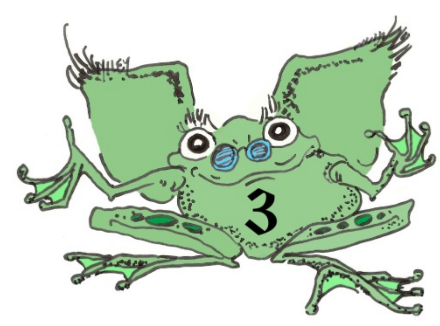
2. Students will analyze each of the lines on the graph.
   Which car is traveling the fastest?
   What do you notice about the slope of the line?

3. Students will calculate the slope of each of the lines. At this level, students should be able to recall the formula for finding slope. As a reminder, the formula is given to them on the first problem. They should also be able to choose ordered pairs for each of the lines in order to calculate the slope.

   Slope of Fillmore's line = 1
   Slope of Luigi's line = 1.5
   Slope of Lightning McQueen's line = 2

4. Ask students to think about what else the slope represents. Since we are dividing y (or distance) by x (or time), the slope also represents the speed. Therefore, Fillmore's speed is 1.0 km/min. Luigi's speed is 1.5 km/min. Lightning McQueen's speed is 2.0 km/min.

5. Students will fill in a data table that will help them recognize the relationship between slope and speed. This data table enforces the fact that speed and slope are equal.



6. Find the equation of the line that represents Fillmore. Tell students that every linear relationship has an equation. This equation can be used to gather information about an experiment and predict future results. The equation of a line is written as $\boldsymbol{y = mx + b}$. In this equation, m represents the slope of the line. Students have already calculated this value and recorded it in the data table. The letter b represents the y-intercept. Tell students that the y-intercept is the point at which the line on the graph crosses the y-axis. Ask students to find the y-intercept for Fillmore. Students should realize that the line will intercept the y-axis at (0, 0). Discuss with students why this happens. In 0 seconds, it is not possible for the car to travel any distance. Therefore, the y-intercept must always be 0. Using this information, students can write the equation for Fillmore's line.

   Equation of Fillmore's line: $y = 1(x) + 0$
   Equation of Luigi's line: $y = 1.5(x) + 0$
   Equation of Lightning McQueen's line: $y = 2(x) + 0$

7. Now students will use the equation of one of the lines to gather information and make predictions. Students should show their work, using the formula provided.

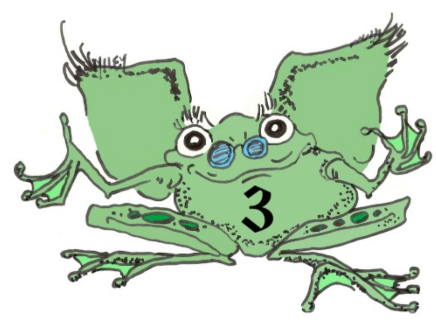
8. Discuss with students that all three cars are traveling at a constant speed. This is why all of the lines are straight. Tell students that a change in speed or direction is called <u>acceleration</u>. Ask students to predict what the line would look like if Fillmore's speed increased. Students will draw the line on a graph. Ask students to predict what the line would look like if Fillmore's speed decreased. Students will then draw that line on the graph.

Day 3 — Lab Activity: A Race Against Time

Activity Setup: In a classroom with six lab tables, you will need six battery-operated toy cars—two each of three different kinds of cars. Each lab table will have one car, three metersticks, one stopwatch, and one calculator. In order to complete this lab, students will rotate to three different lab tables to collect data. Each lab table will have a different kind of car.

1. Distribute the lab handout, "A Race Against Time."

2. Complete the introduction with the students.
   State the problem: Which toy car has the fastest speed?
   Gather information: $\text{Speed} = \dfrac{\text{Distance}}{\text{Time}}$



Prediction: If I time the ________________car for 4 seconds, then it will travel the ______________________ to win the race.
(Students must predict which one of the three cars will travel the longest distance in 8 seconds.)

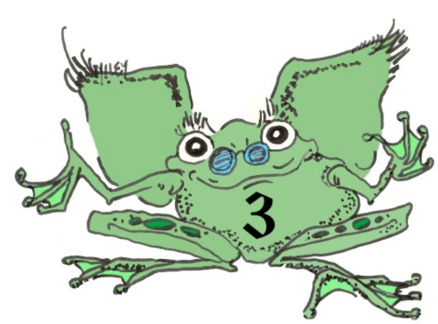
Materials for each lab table: 3 toy cars, 3 metersticks, 1 stopwatch, 1 calculator

3. Discuss the procedure with the students:
   a. Assign roles within the group. You will need one timer, at least one official, and one driver.
      i. Timer: This student will use the stopwatch to monitor the times.
      ii. Official: This student will be responsible for determining the distance the car traveled in a given time.
      iii. Driver: This student will be responsible for letting the car go at the start line.
   b. Line up the metersticks on the floor and turn on the car.
   c. When the timer says "go," the driver should release the car on the start line.
   d. Time the car for 4 seconds.
   e. At the end of 4 seconds, the timer will say "stop." The official will determine the distance the car traveled by using the metersticks. Record data.
   f. Repeat steps 3-5 for two more trials.
   g. Calculate the average distance the car traveled in 4 seconds.
   h. Repeat steps 3–7 for 6 seconds and again for 8 seconds.
   i. Rotate to the next two lab tables to complete the experiment for the remaining cars.

4. The data collected for each of the cars will be recorded in a data table.
   Students will use the average distance for each of the cars to calculate the speed in a separate table.

5. <u>PLEASE NOTE:</u> YOU OR THE STUDENTS MAY DECIDE THAT IT IS EASIER TO MEASURE THE TIME IT TAKES EACH CAR TO TRAVEL A SPECIFIED DISTANCE. THIS IS FINE; HOWEVER, THIS WILL MAKE YOUR INDEPENDENT (MANIPULATED) VARIABLE DISTANCE RATHER THAN TIME AND THE SLOPE OF THE LINE WILL BE TIME/DISTANCE RATHER DISTANCE/TIME. YOU CAN TELL THE STUDENTS TO PLOT THE VARIABLES DIFFERENTLY FOR THIS EXPERIMENT BUT THIS MAY BE CONFUSING TO THEM.

6. Conclusion Question: Why is it important to find an average distance?



Day 4 — Speed Lab Analysis Level 1 (Activity: A Race Against Time)

1. Set up the graph that represents the time and distance traveled for each of the cars.
    a. Ask students to decide which variable will go on the *x*-axis and which variable will go on the *y*-axis. (SEE NOTE ABOVE.) Remind students to use MIX and DRY. Students should realize that time is the manipulated variable, or the variable they change. Therefore, it should go on the *x*-axis. Distance traveled is the responding variable, or the data they are collecting. Therefore, it should go on the *y*-axis.

    b. Students will also need to decide on an interval for the *x*- and *y*-axes. Point out that everyone can have the same interval for the *x*-axis because all of the students used 4, 6, and 8 seconds. However, the *y*-axis interval will be dependent on each group's data, though the results should be similar. Remind students that they must take into account the range of distances they recorded for all three cars. The interval must include the shortest distance as well as the longest distance.

    c. Develop a key for the graph. Each car should be represented with a different color.

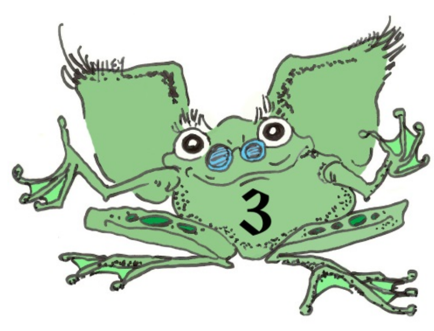
    d. Plot the time and average distance for car 1. Connect the points with a line. Plot the time and average distance for car 2. Connect the points with a line. Plot the time and average distance for car 3. Connect the points with a line.

    e. Add an appropriate title to the graph.

2. Answer conclusion questions about the graph. These questions will require students to interpret the graph.
    a. Which car travels the fastest?
    b. What do you notice about the steepness of the line for this car?
    c. Approximately how far did car 1 travel in 5 seconds? (Students must use their graph to answer this question.)
    d. On a line graph, how can you tell if a car is traveling at a constant speed?

Day 4 — Speed Lab Analysis Level 2

1. The students will set up the graph that represents the time and distance traveled for each of the cars, using the directions in the lab handout.
   Remind them that:
   MIX = manipulated, independent, *x*-axis
   DRY = dependent, responding, *y*-axis
    a. Label the *x*-axis and the *y*-axis. (SEE NOTE ABOVE.)



2. Students should answer the conclusion questions about the graph. These questions will require students to interpret the graph.
3. Students will calculate the slope of the car that traveled at the fastest speed. Remind students that in order to get the most accurate answer, they must use points that fall on their trend (best-fit) line.
4. Ask students to recall what else the slope of a line represents. They should remember that the slope of the line also represents the speed of the car.

Day 4 — Speed Lab Analysis Level 3

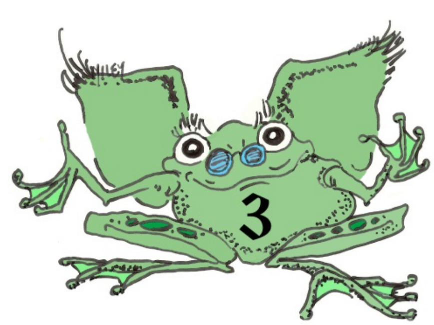
1. Students will use the table for each car to graph the relationship between time and distance. (SEE NOTE ABOVE ABOUT SETTING UP AXES.) This will be a linear relationship. Tell students that this means all of the lines will be straight. Since this is a Level 3 lesson, students should be able to recall the steps for creating an accurate line graph. In this case, they will be drawing a trend (best-fit) line in a scatter graph rather than a line graph. Explain to the students that the objective is to find the relationship between the time and the distance traveled—not the relationship between each individual set of data points.
2. Answer the conclusion questions about the graph. These questions will require students to interpret the graph.
   a. Which car travels the fastest?
   b. What do you notice about the slope of the line for this car?
   c. Approximately how far did car 1 travel in 5 seconds? (Students must use their graph to answer this question.)
   d. On a line graph, how can you tell if a car is traveling at a constant speed?

3. Calculate the slope of the trend line for each car. Remind students that in order to get the most accurate answer, they must use points that fall on their trend line. At this level, students should be able to recall the formula for finding the slope of a line. They can also refer back to yesterday's notes. They must show the formula, the substitution, and the final answer.

4. Ask students to recall what else the slope of a line represents. They should remember that the slope of the line also represents the speed of the car.

5. Write the equation of a line. Remind students of the general formula for a line Fill in the data table.

6. Students will use the equation of the line for the fastest car to gather information about x and y.



7. Conclusion Question:

Given the equation $y = 4x + 2$,

what is the slope of the line?

what is the y-intercept?

If x is 12, what is the value for y? Show your work.

Day 5

Administer the appropriate assessment.