

Ozobot Evo Classroom Application: Simulation of an Experiment in Viscosity

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Introduction

Loosely speaking, viscosity is a measure of a fluid's resistance to flow. Water flows more easily than canola oil, and canola oil flows more easily than molasses. The greater the resistance is to flow, the greater the viscosity of the fluid. Therefore, the viscosity of water is less than the viscosity of canola oil, which is in turn less than the viscosity of molasses.

Probably the most common way to measure viscosity of a fluid is to time the fall of a steel sphere in a long vertical tube containing the fluid. The greater the time it takes to fall a given distance, the greater the viscosity of the fluid. The *SI* (*I*nternational *S*ystem of Units) for viscosity is the pascal second (Pa s). However, a more commonly used unit in engineering practice is the *ISO* (*I*nternational *S*tandards *O*rganization) *viscosity grade*, especially with reference to viscosity differences in oils. Viscosity is also dependent upon the temperature of the fluid, and can vary significantly for oils, such as those used in automobiles, over a relatively small temperature change. As a result temperature should be kept constant when comparing viscosity of various grades of oil.

In this classroom application, Ozobot Evo will be used to simulate an experiment in viscosity. Evo will represent a steel ball that is "falling" in "tubes" containing "oils" with varying viscosities. The "tubes" are printed on a map that Evo will be traversing during the experiment. For ready reference while discussing the experiment, a small copy of the map is shown in Figure 1. A full-page version that can be printed for actual use with Evo appears on the last page of this document.

There are four "tubes" of different colors on the map. Each of the colors is intended to represent oils with different viscosities. The ISO viscosity grade is indicated at the bottom of the map. The viscosity of the red oil is 44, the green oil 31, and the blue oil 12. The yellow oil is labeled with viscosity X, *i.e.*, unknown, and will be used by the students to determine the viscosities of three oils whose viscosities are unknown.

Using a stopwatch or timer app on a cell phone, the students will measure the time for Evo to traverse each of the first three (red, green, and blue) tubes five times, find the average travel time for each, and then plot a graph of travel time vs. ISO viscosity grade. (See pages 4 and 5.) Viscosity is the control variable (independent variable) and is plotted along the x-axis of the graph. Travel time is the dependent variable and is plotted along the y-axis. Travel times are measured from the time that Evo crosses the horizontal gray line at the top of each tube until he crosses the horizontal gray line at the bottom of each tube. The distance between these two lines for each of the tubes is the same. Therefore, the velocity of Evo is proportional to his travel time.

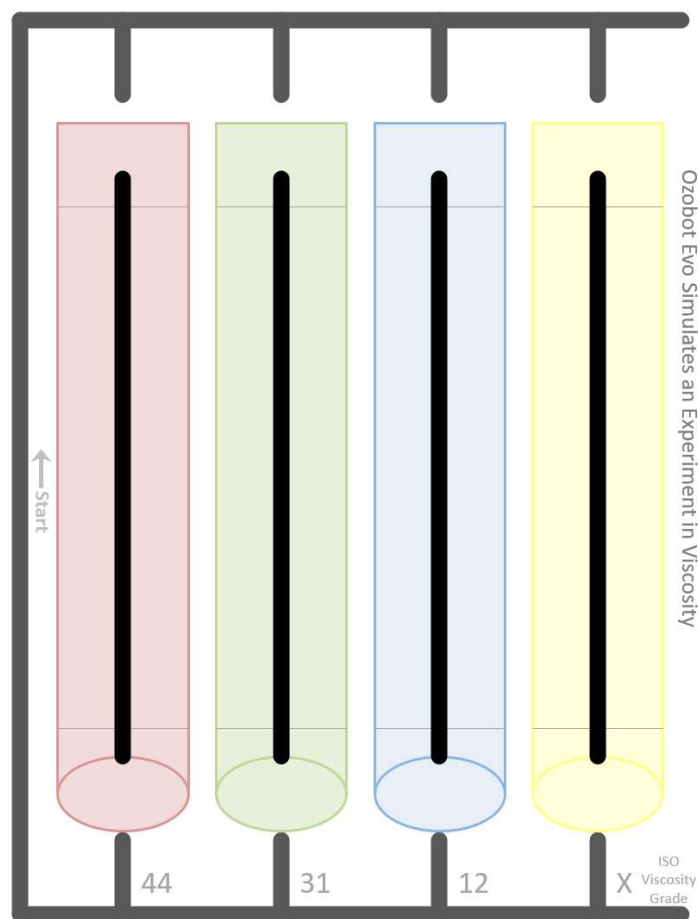


Figure 1

After completing the graph of travel time vs. viscosity, the students will then determine the viscosity of three unknown oils using the yellow tube on the far right of the map. They do this by measuring the travel times for the unknowns and then interpolating or extrapolating on their graph to determine the viscosities. The students will get a good feel for the difference in confidence in interpolation as compared to extrapolation.

Procedure

1. General Considerations
 - a. Make sure that Evo's battery is fully charged.
 - b. All programs for this classroom application require that Evo be placed on the heavy black line on the far left of the map at the location labeled "Start" and facing the direction shown by the arrow.
 - c. *Each student lab group will need a stopwatch or a time app on a cell phone that displays times to a precision of tenths of a second.*
2. Make copies of the Ozomap at the end of this document, as well as the data tables and graphs on pages 4 and 5 for each lab group.
3. The students will begin travel time data collection with the known red, green, and blue viscosity tubes. This requires that Evo be loaded with the OzoBlockly program *KnownViscosities.ozocode* (share code is **esswfp**). Ozobot will first traverse the red tube, then the green tube, and finally the blue tube. He will

repeat this process until he is turned off or runs out of battery charge. The students will need to use their stop watches or time cell phone apps to measure the travel time between the top and bottom gray line for each tube. They can record their travel times in the table at the top of page 4. After collecting data for five trials for each of the three tubes, the students can then calculate the average travel time for each tube and record these averages at the bottom of the table.

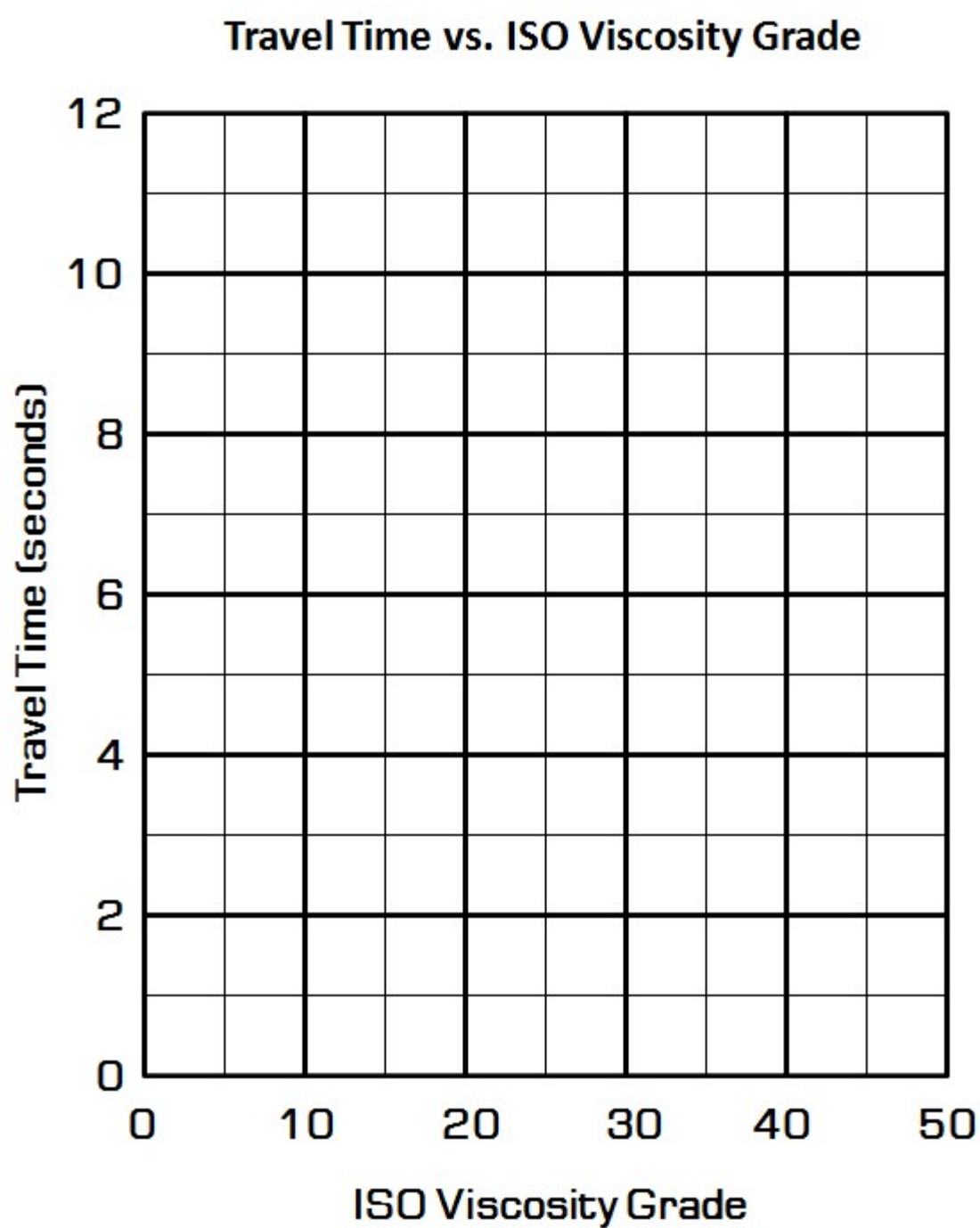
4. The students should now plot the three data points on the graph shown on page 5. It is likely that the three points will not lie on a straight line. Encourage them to draw a *smooth curve* that fits the three points nicely. They now have a graph that will allow them to interpolate or extrapolate the ISO viscosity grade from measurements of the travel times for some unknown simulated “oils”.
5. There are three unknown “oils” for which the students can determine the ISO viscosity grade from measurement of travel time by either interpolation or extrapolation on the graph. To do the first of the unknown oils, the student will need to load Evo with the file *UnknownViscosity1.ozocode* (share code is **fo2zhk**). Evo will make repeated traversals of the yellow tube, allowing the student to fill in travel time data in the table at the bottom of page 4. The student can then compute and record the average travel time for five trials at the bottom of this table. This average can be used to interpolate or extrapolate in the graph in order to obtain the ISO grade viscosity of the unknown. The student should record the viscosity in the blank cells near the top of the table for unknown viscosities.
6. Repeat step 5 but this time the student should load the file *UnknownViscosity2.ozocode* (share code is **4ygn4d**).
7. Repeat step 5 one last time by loading the file *UnknownViscosity3.ozocode* (share code is **a8cmie**).
8. Unknown viscosities 1 and 2 involve interpolation in the graph, while unknown viscosity 3 involves extrapolation. It would be good to have the class discuss their thoughts as to which of the two is more “risky”—interpolation or extrapolation.

Teacher Note #1: *Typical lab results for the data table and graph are shown on page 6. There may be some variance from one Evo to another. Remember that the experiment should be started with a fully charged Evo.*

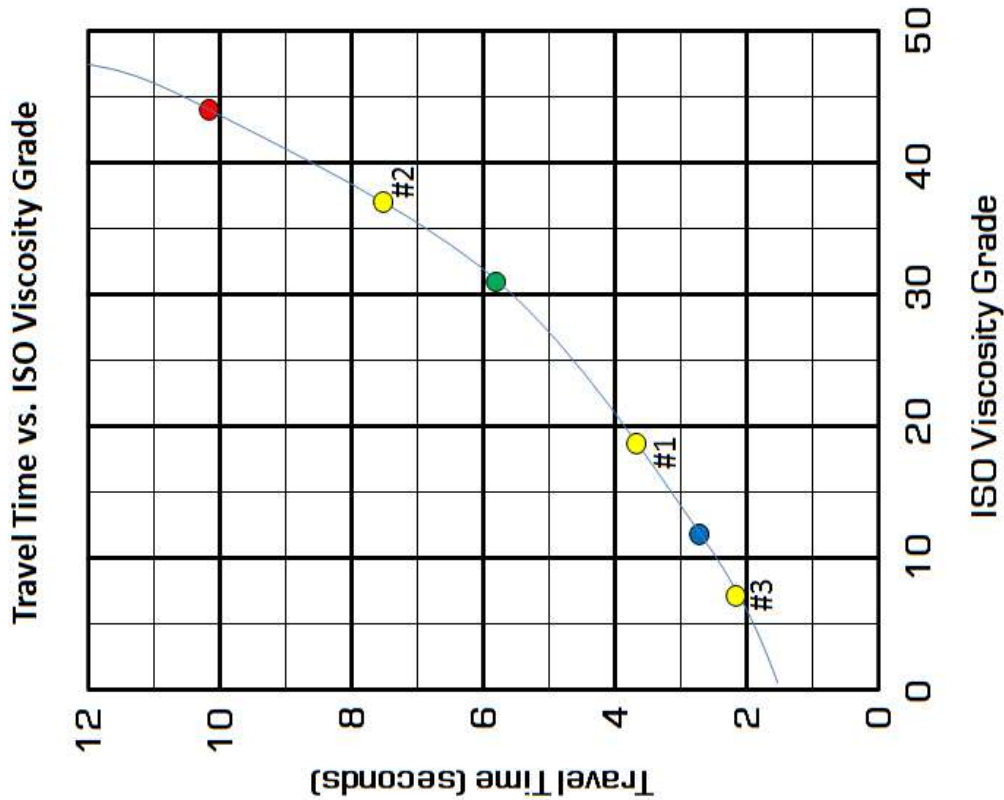
Teacher Note #2: *If the teacher is interested in having the class perform a similar experiment with actual tubes filled with oils of a variety of ISO viscosity grades, you can visit Educational Innovations, Inc. at www.TeacherSource.com. They have a product called “VIS-10: Viscosity of Oil Tubes” that sells for \$38.95, based upon prices effective on 4/16/2021.*

Travel Times (seconds) for Known Viscosity Fluids			
Trial	ISO Grade Fluid Viscosity		
	44	31	12
	Red	Green	Blue
1			
2			
3			
4			
5			
Average			

Travel Times (seconds) for Unknown Viscosity Fluids			
Trial	ISO Grade Fluid Viscosity		
	Unknown #1	Unknown #2	Unknown #3
1			
2			
3			
4			
5			
Average			



Typical Viscosity Lab Results



Travel Times (seconds) for Known Viscosity Fluids			
Trial	ISO Grade Fluid Viscosity		
	44	31	12
	Red	Green	Blue
1	10.6	5.8	2.8
2	9.9	5.8	2.8
3	10.0	5.9	2.8
4	10.0	5.9	2.8
5	10.0	5.9	2.8
Average	10.1	5.86	2.8

Travel Times (seconds) for Unknown Viscosity Fluids			
Trial	ISO Grade Fluid Viscosity		
	19	37	7
	Unknown #1	Unknown #2	Unknown #3
1	3.9	7.6	2.2
2	3.8	7.5	2.2
3	3.8	7.5	2.3
4	3.8	7.6	2.3
5	3.7	7.6	2.1
Average	3.8	7.56	2.22

Ozobot Evo Simulates an Experiment in Viscosity

