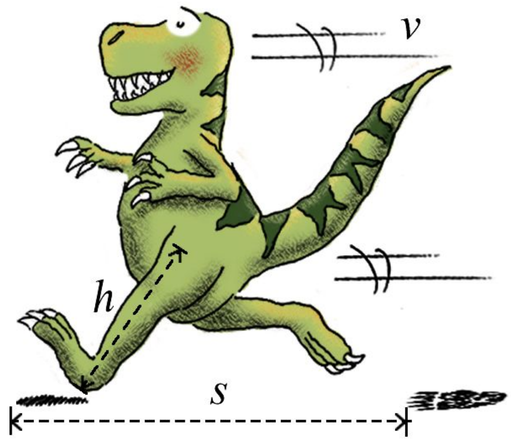
Running with Dinosaurs Lesson Plan (Grades 6-8)

Objectives

- Explain how the Alexander Formula is used to estimate dinosaur running velocities
- Measure hip height and footprint track data on class members
- Test the Alexander Formula using class members



Materials:

- Metersticks
- Tape
- Stopwatch (Cellphone Optional)
- Clipboard
- Pencils
- Calculator with exponent capabilities
- Graph Paper
- Running with the Dinosaurs Data Activity Sheet
- Running with the Dinosaurs Data Answer Key
- Running with the Dinosaurs Analysis Sheet
- Running with the Dinosaurs Analysis Answer Key
- Computer Spreadsheet (optional)
- Butcher paper (optional)

Instructional Plan:

Begin class by watching a clip They're Flocking This Way from the film Jurassic Park (https://www.youtube.com/watch?v=nM-RPO10aPY) to show the students a visual of humans running with dinosaurs (stop video at 1:12). Then discuss what information we have about dinosaurs that would allow us to create a model about their motion. Think about paleontology clues such as fossilized bones and preserved footprints. After discussing the information available about dinosaurs, begin discussing tools researchers need to construct a dinosaur motion model. Can the students think of any animals that are alive today that are similar to dinosaurs in shape, size, or structure? What about these modern animals can help us with our dinosaur motion model?

Discuss the work of R. McNeil Alexander which pertained to the formula to estimate the running velocity of dinosaurs. He created his formula by using data gathered from observing ostriches. He looked at the relationship between the stride length(s) and hip height (h) of the ostriches to estimate running velocities. The formula is:

$$v = (.78s^{1.67}) / h^{1.17}$$

where *v* represents the velocity (in meters per second) at which an animal runs; *s* represents stride length (in meters), the distance between consecutive steps of the same foot, and *h* is the hip height (in meters) of the animal measured from the top of the hip, or the iliac crest, to the ground.

Now, let the students know they will be running an experiment using Alexander's Formula to validate his results. The students will serve as bipedal dinosaurs. The students need to form groups of 3-4. Each group will need the following material for the trials:

- Meter stick
- Tape for marking "Start" and "Finish" on a measured running track
- Stopwatch (Cellphone Optional)
- Running with Dinosaurs Data Activity Sheet
- Pencil
- Clipboard

The groups will be running their trials out of doors, preferably a track, so they can run safely for 30 meters. Each group needs to measure and mark off a 30-meter straight-line, again this will be easiest to do on a track. Make sure the students record the distance in the Distance column of their Running with the Dinosaurs Data Activity Sheet. Students need to make sure they mark the start and the finish line on the ground. Each student in the group should take turns running the track. During each of these runs, there should be one student counting the number of steps taken by the runner, and another student using the stopwatch to time the run. In order to avoid the lagging ramp-up time, students should start their run before the start line, but not start timing the run until the student crosses the start line. Following each of the trail runs, students need to record the Run Time and the Number of Steps on the activity sheet.

Back in the classroom, use the same groups that performed the trials to find the actual velocity (in meters per second). Remind the students the formula for velocity is distance over time. Now, the students need to use a meterstick to measure each student's hip height. They will need to measure the straight-line distance from the floor to the top of the hip, which is about the same height as the belly button. The students then will need to record the hip height measurement on the activity sheet. If necessary, the students can round to the nearest tenth of a meter. Remind the students

Finally, groups should use their calculators and their Data Activity sheets to compute and record the estimated velocity of each student using the Alexander Formula. Ask each group to create, on graph paper or on the computer, a simple plot comparing actual and predicted velocity measurements for each of its members. Use predicted velocity on the *y* -axis and actual velocity on the *x* -axis. Look at plot of ordered pairs to see if a correlation between actual and predicted velocities exist.

8th Grade Extension:

Using the Data Activity Sheet, let the students graph their hip height versus their velocity to determine if there is a linear relationship between the two. Then, have students compare their hip height to that of a brontosaurus (or a different dinosaur). After they find the speed of the brontosaurus (or a different dinosaur), they can compare it to their own as well as some of their classmates'. One large poster can be created to be displayed in the classroom.

Differentiation:

- Struggling students can check their computations against an online calculator for Alexander's formula.
- Prior to distributing the data sheet, ask students to brainstorm how they could set up an experiment to test Alexander's Formula. If students come up with a slightly different (yet teacher approved) approach to comparing the actual velocity to the predicted velocity, let them use their model.

Assessment Options:

1. Invite each student to create a mini-poster featuring "The Alexander Formula and Me." Have students work individually to draw or photograph and print front and side images of themselves, then label their hip height and step length in the images. Then have each student write the Alexander Formula and solve it for his or her personal data. They can also include a title, word bubbles, and a statement regarding how well the formula compared with their actual running velocity. Display posters for class presentation and discussion.
2. Have student groups write a brief analysis of their research in the form of an "executive summary" using the Running with the Dinosaurs Analysis Sheet. Encourage them to respond to the question prompts in paragraph form, assigning different students to each prompt. Assign one student in the group the responsibility of including multiple representations of the group's work in the form of diagrams, photos, formulas, data charts, and graphical plots. Invite students to engage in peer revision with members of their group before submitting a final version of their analysis.

Extensions:

1. Use connected large sheet of graph paper to create an actual vs. predicted velocity plot that includes all members of the class. Discuss whether the larger data set provides additional information or insight in determining how well the Alexander Formula "works" for humans.
2. Have students work as a class to create a shoebox diorama of the Jurassic period including terrain and toy bipedal dinosaurs (available at most craft stores). Ask students

to use the Alexander Formula to compute the predicted running velocities of the dinosaurs based on the toy figures. Students will first need to do some research to determine the scale of the figure, then compute an estimated hip height and stride length before applying the formula. Complete the diorama with placards showing the name of each dinosaur, the scale, and the computed running velocities.

3. Alexander's original formula has been simplified for this activity. His original formula actually incorporates g , the acceleration due to gravity at Earth's surface. Look up his original formula and discuss how it could be modified to compute a predicted running velocity for each student on other celestial bodies such as Mars or the moon!

Tennessee Mathematics Standards:

6th Grade:

Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equations.

Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

7th Grade:

Solve real-world and mathematical problems involving the four operations with rational numbers.

Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

8th Grade:

Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, and nonlinear association.

Know that straight lines are widely used to model relationships between two quantities variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.

Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept.

Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x,y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms its graph or a table of values.

Source:

McCue, C. 2015. Running with Dinosaurs. Classroom Resources: Illuminations, National Council of Teachers of Mathematics.

Adapted by Virginia Parkman, Kelly Sturner, and Suzanne Lenhart

Movieclips, Jurassic Park (6/10) Movie CLIP - They're Flocking This Way! (1993) HD. **https://www.youtube.com/watch?v=nM-RPO10aPY**

Running with the Dinosaurs Data

Measure and record your data for Trial 1 and Trial 2. Then, compute the actual velocity (v_a) and the predicted velocity (v_p) using Alexander's Formula.

1. Trial Data

	DISTANCE (m)	TIME (s)	NUMBER OF STEPS	ACTUAL $v_a = \frac{\text{Distance}}{\text{Time}}$ (in m/s)	STRIDES = $\left(\frac{\text{Steps}}{2}\right)$	STRIDE LENGTH (s) = $\left(\frac{\text{Distance}}{\text{Strides}}\right)$ (m)	HIP HEIGHT (h) (m)	PREDICTED $v_p = \frac{0.78s^{1.67}}{h^{1.17}}$ (in m/s)
	Trial 1							
	Trial 2							
	Trial 1							
	Trial 2							
	Trial 1							
	Trial 2							
	Trial 1							
	Trial 2							

Transfer the values of the actual and predicted velocities from Trials 1 and 2 to the following chart. Then, compute the mean actual and predicted velocities for each student in your group.

STUDENT NAME	ACTUAL VELOCITY (in m/s)			PREDICTED VELOCITY (in m/s)		
	TRIAL 1	TRIAL 2	MEAN	TRIAL 1	TRIAL 2	MEAN

2. Plot the mean actual and predicted velocities for each student in using computer software. Examine the values and the plot. How well do the actual and predicted velocities correlate for each member of your group and the group as a whole?

Name: ________________________

Running with the Dinosaurs Analysis

Write a brief analysis of the Running with the Dinosaurs exploration. Include your data charts and velocity plot in your document. You may also choose to include drawings or photos to illustrate your work. Incorporate answers to the following questions in your response.

1.) Studying the behavior and motion of dinosaurs is obviously a challenge since these creatures are extinct. What information do researchers need to model the running velocity of a dinosaur?

2.) Research online, then state and discuss the Alexander Formula. What do the variables mean? What is straide and how is it measured? Does the Alexander Formula apply only to two-legged runners? How was this formula derived?

3.) Describe the human trials we conducted to test the Alexander Formula. How did we devise our setup for collecting data? What variables did we measure? What did we do with the collected data? What potential errors exist in our data and computations? How can these errors be reduced?

Answer Key – Running with the Dinosaurs Data

Measure and record your data for Trial 1 and Trial 2. Then, compute the actual velocity (v_a) and the predicted velocity (v_p) using Alexander's Formula.

1. Trial 1 Data

[Sample data given for one student]

STUDENT		DISTANCE (m)	TIME (s)	NUMBER OF STEPS	ACTUAL $v_a = \frac{\text{Distance}}{\text{Time}}$ (in m/s)	STRIDES $\left(\frac{\text{Steps}}{2}\right)$	STRIDE LENGTH (s) $\left(\frac{\text{Distance}}{\text{Strides}}\right)$ (m)	HIP HEIGHT (h) (m)	PREDICTED $v_p = \frac{0.78s^{1.67}}{h^{1.17}}$ (in m/s)
Joe Jones	Trial 1	30	3.9	14	7.7	7	4.3	0.91	9.9
	Trial 2	30	3.7	15	8.1	7.5	4	0.91	8.8
	Trial 1								
	Trial 2								
	Trial 1								
	Trial 2								
	Trial 1								
	Trial 2								

2. Transfer the values of the actual and predicted velocities from Trials 1 and 2 to the following chart. Then, compute the mean actual and predicted velocities for each student in your group.

[Sample answer for one student provided]

STUDENT NAME	ACTUAL VELOCITY (in m/s)			PREDICTED VELOCITY (in m/s)		
	TRIAL 1	TRIAL 2	MEAN	TRIAL 1	TRIAL 2	MEAN
Joe Jones	7.7	8.1	7.9	9.9	8.8	8.2

3. Plot the mean actual and predicted velocities for each student in your group below or using computer software. Examine the values and the plot. How well do the actual and predicted velocities correlate for each member of your group and the group as a whole?

[Graphs will vary.]

Answer Key – Running with the Dinosaurs Analysis

Write a brief analysis of the Running with the Dinosaurs exploration. Include your data charts and velocity plot in your document. You may also choose to include drawings or photos to illustrate your work. Incorporate answers to the following questions in your response:
[Answers will vary.]

1. Studying the behavior and motion of dinosaurs is obviously a challenge since these creatures are extinct. What information do researchers need to model the running velocity of a dinosaur?

> Researchers would need dinosaur trackways to determine stride length, and would need fossilized dinosaur skeletons to determine hip height.

2. Research online, then state and discuss the Alexander Formula. What do the variables mean? What is stride and how is it measured? Does the Alexander Formula apply only to two-legged runners? How was this formula derived?

> The variable *s* stands for stride length, and the variable *h* stands for hip height. Stride is the distance between successive prints of the same foot. Stride length can be measured by dividing the distance traveled by the number of strides. The formula applies only to two-legged runners. R. McNeill Alexander came up with the formula while observing ostriches.

3. Describe the human trials we conducted to test the Alexander Formula. How did we devise our setup for collecting data? What variables did we measure? What did we do with the collected data? What potential errors exist in our data and computations? How can these errors be reduced?

> To test the Alexander Formula we set up a track in which there was a given distance, and we determined how many steps it took to cover the distance and how much time it took to cover the distance. We used the distance and the time to calculate actual distance. To determine stride, we counted the number of steps used to cover the distance and divided by two (there are two steps in one stride), and to determine stride length, we divided the strides by the distance covered. Hip height was measured in meters, measuring the standing student from the foot to the iliac crest. There is always the potential for human errors when providing data as well as calculating the data. For example, students might miscount the number of steps a teammate took, or misrepresent the exact point at which the student started and finished running exactly 30 meters.