Teacher Guide: Measuring Motion

Learning Objectives

Students will…

- Use estimation techniques to measure the distance an animal runs or walks.
- Understand the meaning of speed.
  - For example, interpret a speed of 5 m/s to mean that an animal moves 5 meters each second.
- Divide distance by time to calculate speed.
- Measure and compare the running speeds of several African mammals.

Vocabulary

distance, speed

Lesson Overview

The *Measuring Motion* Gizmo™ allows students to observe African animals on a virtual safari. Their assignment is to measure and compare the running speeds of each animal.

The Student Exploration sheet contains two activities:

- Activity A – Students use estimation techniques to measure distance and calculate speed.
- Activity B – Students measure the running speeds of 11 African animals.

Filming a running lion

Suggested Lesson Sequence

1. **Pre-Gizmo activity: How fast can you run?** (20 – 60 minutes)
   Set up a 40-meter racecourse on school grounds. Assign students to be starters and timers, and time how long it takes each student to run the distance. Calculate the speed of each student in meters per second, kilometers per hour, and miles per hour if you like. (There are 1000 meters in a kilometer, 3600 seconds in an hour, and approximately 1.6 kilometers in a mile.) For comparison, an Olympic sprinter can run a 100-meter race in under 10 seconds, averaging slightly more than 10 meters per second!

2. **Prior to using the Gizmo** (10 – 15 minutes)
   Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

3. **Gizmo activities** (15 – 20 minutes per activity)
   Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
   As students are working or just after they are done, discuss the following questions:
   - What techniques can you use to estimate the distance an animal (in the Gizmo) travels?
   - Once you know distance and time, how can you calculate speed?
   - Which animal runs fastest? Which animals run slowest?
   - Why is it important for the fast animals to be fast?
   - How do the slow animals survive?

5. **Follow-up activity: Who are the fastest animals?** (10 – 20 minutes)
   Ask students to conduct research on which animals hold the world records for speed. Look for the fastest animal on land, the fastest in the air, and the fastest in the sea. Think of other interesting speed records as well, such as the fastest land animal on each continent, the fastest dinosaur, etc.

   In the course of their research, students might find an incredible disparity in reported speed values. For example, at least two websites state that the spine-tailed swift was clocked flying at close to 100 m/s, while others agree that its top speed is closer to 50 m/s. Point out the importance of getting several sources of information, and discuss why it might be difficult for scientists to accurately determine top animal speeds.

Scientific Background

The measurement of speed is one of the fundamentals of physical science. Speed is the distance traveled in a unit of time. Speed is calculated by dividing distance by time: $s = d / t$. This equation can be rewritten as $d = st$. (You may have seen this written as $d = rt$. This is the same equation, but uses r for "rate" rather than s for "speed.")

Measuring distance requires a **frame of reference**, a background that is presumed to be stationary. The importance of a frame of reference can be illustrated by trying to measure the speed of a car on a highway. This sounds simple enough until you consider that relative to the Moon, the car is moving at a speed of approximately 1,500 km/hr due to Earth's rotation. Relative to the Sun, the car is also moving over 100,000 km/hr due to Earth's revolution. The solar system is moving at a rate of over 800,000 km/hr around the center of the Milky Way Galaxy, and the whole galaxy is moving at a rate of over 1,000,000 km/hr towards the Andromeda Galaxy, our nearest neighbor!

Luckily, for motions that occur on Earth, it is perfectly valid to choose the most convenient frame of reference, Earth itself. As long as Earth is considered to be stationary it is simple to calculate the speed of a car. The speed of the solar system and the Milky Way won't affect how long it takes you to drive to the supermarket.

Physicists tend to use the more descriptive term **velocity** rather than speed. Velocity specifies both speed *and* the direction of motion. If motion from left to right is defined as having positive velocity, then motion from right to left has negative velocity. A car that completes an oval racecourse might have an average *speed* of 300 km/hr, but its average *velocity* is zero.

Acceleration (*a*) is defined as a change in velocity (*v*) in a given period of time (*t*), $a = \Delta v / t$. (The Greek letter delta, Δ, is commonly used to mean "change in.") Isaac Newton discovered that any kind of acceleration requires a force. It requires a force to speed up or slow down a moving object, and it also requires a force to change the direction of a moving object. (Recall that changing an object's direction will also change the object's velocity.)

On the African savannah, where there are few places to hide from predators, speed is a key component of survival. While animals such as mature elephants and rhinos are protected from predators by their size and thick skin, others must rely on speed and agility to get away.

Typical prey adaptations include long legs, eyes on the side of the head for a greater range of vision, and the tendency to congregate in large herds. As a predator attacks a large herd the individual animals scatter in all directions, possibly confusing the predator.

Thomson's gazelle

Environmental Connection: Conserving African Animals

The African Savannah is famous for its spectacular wildlife. But many of these animals have come under increasing pressure from habitat loss and poaching. The population of African elephants was almost cut in half by poaching during the 1970s and 1980s. An international ivory ban instituted in 1989 has helped the situation, but most elephants today are confined to wildlife preserves.

Another of Africa's endangered mammals is the cheetah. There were approximately 100,000 cheetahs in Africa and Asia at the beginning of the 20th century; today there are less than 13,000. At the current rate of decline, cheetahs will become extinct in less than 20 years. Cheetahs have been hurt by habitat loss and have come into conflict with farmers who shoot them to protect livestock. An additional obstacle is the fact that cheetahs do not survive well on wildlife preserves due to competition from other top predators.

Like their Asian counterparts, Africa's two species of rhinoceros are also threatened. Black rhino populations declined by 90% during the 1970s due to intense poaching, and their current population hovers around 3,000. The Southern White Rhinoceros population has recovered from only about 20 individuals at the beginning of the 20th century to over 11,000 today, but the once abundant Northern White Rhinoceros has been reduced to fewer than 10 individuals living in a national park in the war-torn Democratic Republic of Congo.

Selected Web Resources

Velocity: http://www.gearseds.com/curriculum/images/figures/motion_speed_rev4.pdf
Velocity, Speed, and Motion: http://www.physics4kids.com/files/motion_velocity.html
Measuring speed: http://education.apple.com/education/ilife/lesson_plans/measuringspeed.pdf
Animal speeds (in miles per hour): http://www.factmonster.com/ipka/A0004737.html
Cheetahs: http://www.extremescience.com/Cheetah.htm
African Wildlife Foundation: http://www.awf.org/
Cheetah Conservation Fund: http://www.cheetah.org/