

The Energy of Motion

A RIVER STUDY

Focus Question

What factors affect the kinetic energy of water?

ACTIVITY



Activity Overview

In recent years, Louisiana's coastal wetlands have been disappearing and projects have been started to restore them. Sediment reintroduction projects seek to reverse erosion by diverting sediment carried by the Mississippi River through channels. This sediment is deposited in wetlands eroded areas to form new land. In planning reintroduction projects, engineers must consider the kinetic energy of water. Failure to do so may have costly consequences.

In this activity, you will simulate sediment reintroduction channels using a ramp at two slopes. You will roll a ball, which represents water, down the ramp and measure its velocity using a motion sensor connected to a TI CBL 2™ or Vernier LabPro and a TI-73 Explorer™. You will then find the kinetic energy of the ball at different times as it rolls down the ramp.

How does slope affect velocity? How does velocity affect kinetic energy? How does slope affect kinetic energy? Why is the kinetic energy of water in the Mississippi River important to consider in wetland restoration projects?



The Energy of Motion

A RIVER STUDY

ACTIVITY

Part A — Collect Velocity Data: Steep Slope

Procedure

1 Prepare your ramp.

- Set up a ramp using a rectangular table or board that is at least 1 meter wide and 1.5 meters long. You may create a track using two narrow boards positioned parallel to each other. These boards will ensure that when you roll the ball it will not fall off the sides of the ramp.
- Use bricks or books to raise one end of the ramp to create a steep slope. The slope should be at least 30° . In order to create a steep slope you may set the ramp so that H_1 is 0.5 meters and H_2 is 1.25 meters. This ramp simulates a steep reintroduction channel. (Figure 1)

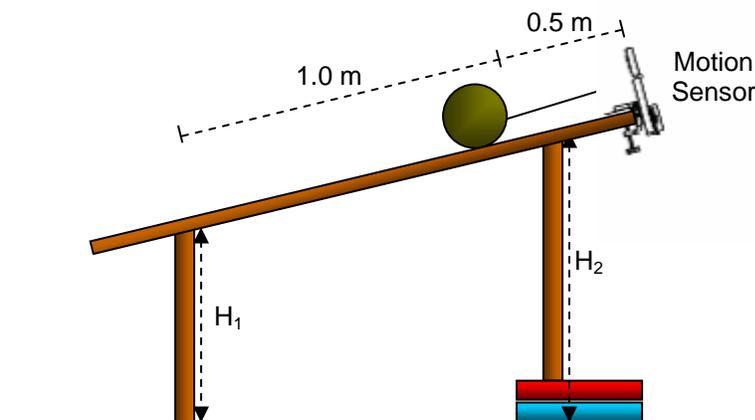


Figure 1

- Clamp the motion sensor at the top of the ramp.
- Measure 0.5 meters from the motion sensor and mark this position on the ramp using a pencil or masking tape.
- Measure 1.5 meters from the motion sensor and mark this position on the ramp using a pencil or masking tape.

2 Connect the motion sensor to the CBL 2™ or Vernier LabPro and TI-73 Explorer™.

- Plug the motion sensor into the DIG/SONIC Port of the CBL 2™ or Vernier LabPro.
- Use the link cable to connect the TI-73 Explorer™ to the interface.
- Firmly press in the cable ends.

3 Set up the TI-73 Explorer™.

- Turn on the TI-73 Explorer™ and start the DATAMATE application. (For instructions on DATAMATE see Appendix A.)
- Press **CLEAR** to reset the program.
- If the DIGITAL CHANNEL (DIG) displays MOTION (M), proceed to Step 3.h. If it does not, continue with this step to set up your sensor manually.
- Select SETUP from the MAIN SCREEN by pressing **1**.
- Use **↑** and **↓** to select DIG: MOTION and press **ENTER**. [: OR - ?]
- Press **1** to select MOTION (M).

Materials*

- TI-73 Explorer™
- TI CBL 2™ or Vernier LabPro
- TI-73 DataMate
- Motion sensor
- Playground or soccer ball
- Balance
- Table or board (at least 1 meter wide and 1.5 meters long)
- Meter stick



TI-73 Explorer™



Motion Sensor



The Energy of Motion

A RIVER STUDY

ACTIVITY

- g. Select OK again to return to the MAIN SCREEN by pressing [1].
- h. In Step 4 you will collect your data. The motion sensor automatically collects time, distance, velocity, and acceleration data. [THIS DOES NOT SEEM LIKE A STEP.]

4 Collect your data for the steep slope.

- a. Place the ball at the first marked position on the ramp 0.5 meters from the motion sensor.
- b. Press [2] on the TI-73 Explorer™ to begin data collection.
- c. Immediately after you hear four beeps, release the ball and quickly pull away. At the end of data collection you will hear two beeps.

5 Crop your data.

In this experiment you are only interested to analyze your collected data between the 0.5 meter mark and the 1.5 meter mark on the ramp. You will crop your data using the SELECT REGION feature to remove unwanted data.

- a. Press [2] to choose SELECT REGION.
- b. Use the arrow keys (←) and (→) to move the cursor along the curve until the Y-axis value is 0.5 meters. Press [ENTER] to set the lower limit at 0.5 meters.
- c. Use the arrow keys (←) and (→) to move the cursor along the curve until the Y-axis value is 1.5 meters. Press [ENTER]. Your distance and time graph will be displayed showing only the region from 0.5 meters to 1.5 meters.
- d. Press [ENTER] to return to the GRAPHING MENU.

6 Graph your velocity data.

- a. Select DIG-]VELOCITY from the GRAPHING MENU to view the velocity and time graph.
- b. Press [ENTER] to see your graph.

↻ *To collect your data again, press [ENTER], then [1] to return to the main screen and repeat Step 4.*

7 Complete the Data Analysis section. Answer the questions in your journal.

Data Analysis

While observing the graph, press [TRACE] and use the arrow keys (→) and (←) to move the cursor along a line. The X-coordinate (time) and Y-coordinate (velocity) of each data point are displayed below the graph.

Make a sketch of your graph in your journal and label it *Velocity and Time: Steep Slope*. Label the X-axis *Time (s)* and the Y-axis *Velocity (m/s)*.

- 1** By observing your graph, describe how the velocity of the ball changed as it rolled down the steep slope ramp.
- 2** Copy Table 1 into your journal.



The Energy of Motion

A RIVER STUDY

ACTIVITY

Table 1

	Steep Slope Ramp				Gentle Slope Ramp		
	Time (s)	Velocity (m/s)	Mass (kg)	KE (J)	Velocity (m/s)	Mass (kg)	KE (J)
Time A							
Time B							
Time C							

- 3** Select a point at the beginning of the experiment and record the time in seconds next to Time A in Table 1.
- 4** Select a point half way through the experiment and record the time in seconds next to Time B in Table 1.
- 5** Select a point at the end of the experiment and record the time in seconds next to Time C in Table 1.
- 6** Record the velocity for the steep slope ramp at Time A in Table 1.
- 7** Record the velocity for the steep slope ramp at Time B in Table 1.
- 8** Record the velocity for the steep slope ramp at Time C in Table 1.
- 9** At which time (Time A, Time B, or Time C) was the velocity of the ball the least?
- 10** At which time was the velocity of the ball the greatest?
- 11** Use the balance to measure the mass of the ball in grams and record the value in the table in kilograms (1000 grams = 1 kilogram). You will use the same ball for both experiments, so record the mass in all table cells under both Mass columns.

River water moving at a high velocity has enough kinetic energy to carry sediment downstream. Kinetic energy is the energy due to motion. Any moving object has some kinetic energy. You can calculate the kinetic energy (KE) of the ball using the formula

$$KE = \frac{1}{2} \times m \times V^2$$

where m is the mass of the ball in kilograms and V is its velocity in meters per second. Kinetic energy is measured in units of Joules (J).

- 12** Use the KE formula to calculate the kinetic energy of the ball for the steep slope ramp at each of the three times. Enter the values in Table 1. You may use your TI-73 Explorer™ to perform the calculations.
- 13** At which time was the kinetic energy of the ball the least?
- 14** At which time was the kinetic energy of the ball the greatest?



The Energy of Motion

A RIVER STUDY

ACTIVITY

Part B — Collect Velocity Data: Gentle Slope

Procedure

1 Collect your data for the gentle slope.

- Remove bricks or books to lower the raised end of the ramp to create a gentle slope. The slope should be about 10° . In order to create a gentle slope, you may set the ramp so that H_1 is 0.5 meters and H_2 is 0.75 meters.
- Press **ENTER** to return to the GRAPHING MENU.
- Press **1** to return to the MAIN SCREEN.
- Place the ball at the first marked position on the ramp 0.5 meters from the motion sensor.
- Press **2** on the TI-73 Explorer™ to begin data collection.
- Immediately after you hear four beeps, release the ball and quickly pull away. At the end of data collection you will hear two beeps.

2 Crop your data.

- Press **2** to choose SELECT REGION.
- Use the arrow keys (**◀** and **▶**) to move the cursor along the curve until the Y-axis value is 0.5 meters. Press **ENTER** to set the lower limit at 0.5 meters.
- Use the arrow keys (**◀** and **▶**) to move the cursor along the curve until the Y-axis value is 1.5 meters. Press **ENTER**. Your distance and time graph will be displayed showing only the region from 0.5 meters to 1.5 meters.
- Press **ENTER** to return to the GRAPHING MENU.

3 Graph your velocity data.

- Select DIG-VELOCITY from the GRAPHING MENU to view the velocity and time graph.
- Press **ENTER** to see your graph.

↪ To collect your data again, press **ENTER** then **1** to return to the main screen and repeat Step 1.

4 Complete the Data Analysis section. Answer the questions in your journal.



The Energy of Motion

A RIVER STUDY

ACTIVITY

Data Analysis

While observing the graph, press **TRACE** and use the arrow keys (**▶** and **◀**) to move the cursor along a line. The X-coordinate (time) and Y-coordinate (velocity) of each data point are displayed below the graph.

Make a sketch of your graph in your journal and label it *Velocity and Time: Gentle Slope*. Label the X-axis *Time (s)* and the Y-axis *Velocity (m/s)*. You may sketch the velocity from Part A and Part B on the same graph.

- 1 By observing your graph, describe how the velocity of the ball changed as it rolled down the gentle slope ramp.
- 2 Record the velocity for the gentle slope ramp at Time A in Table 1.
- 3 Record the velocity for the gentle slope ramp at Time B in Table 1.
- 4 Record the velocity for the gentle slope ramp at Time C in Table 1.
- 5 At which time was the velocity of the ball the least?
- 6 At which time was the velocity of the ball the greatest?
- 7 Compare the velocity of the ball for the two slopes as time increased from Time A to Time C.
- 8 Calculate the kinetic energy (KE) of the ball for the gentle slope ramp at all selected times. Enter the values in Table 1.
- 9 At which time was the kinetic energy of the ball the least?
- 10 At which time was the kinetic energy of the ball the greatest?
- 11 Compare the kinetic energy of the ball for the two slopes as time increased from Time A to Time C.
- 12 Based on your data from Table 1, how did kinetic energy change when velocity increased?
- 13 Based on your data from Table 1, how did kinetic energy change when slope increased?
- 14 Based on your data from Table 1, how did velocity change when slope increased?

Like the ball rolling down the ramp, the velocity and energy of water in the Mississippi River increases as it flows downstream. The energy of moving water is kinetic energy. The slope of the river bed affects the velocity and kinetic energy of the water in a similar manner as the slope of the ramp affected the velocity and kinetic energy of the ball.

As river water flows downstream, it applies a force on sediment, which is then carried over some distance. The use of force to move an object over a distance is called work. River water moves sediment over a distance by doing work. The ability of water to do work depends on its energy. The more kinetic energy water has the more work it can do.



In order to successfully restore wetlands, engineers must divert sediment and deposit it in eroded areas. Sediment reintroduction projects rely on the energy of moving water to do work. The moving water carries massive amounts of sediment through a *sediment reintroduction channel* into eroded wetland areas.

- 15** Based on the results of your investigation describe how engineers can control the energy of the moving water as it moves sediment through the channel and deposits the sediment into the eroded wetland areas.

Table 2 represents two wetlands locations. Copy Table 2 into your journal.

- 16** *Location 1* represents a sediment reintroduction channel. Using the terms *high* or *low*, describe the velocity of the moving water in the channel. Use the same terms to describe the kinetic energy of the moving water. Record your choices in the table.

Location 2 represents a wetlands eroded area. In order for the sediment to be deposited successfully, the velocity and kinetic energy of water in the channel and eroded areas must be appropriate. Using the terms *high* or *low*, describe the velocity of the moving water in the eroded areas. Use the same terms to describe the kinetic energy of the moving water. Record your choices in the table.

Table 2

Location		Velocity (V)	Kinetic Energy (KE)
1	Sediment Reintroduction Channel		
2	Wetlands Eroded Area		

- 17** Based on what you learned in this experiment, why do you think more particles carried by the Mississippi River settle near the mouth of the river than upstream?

