Moon River

Summary

The physics lesson demonstrates how classic physics equations, such as measuring the volume of water flowing through a pipe, can be applied to real-world situations. This lesson will teach students how to predict the volume of water that will flow through the inlet of the Columbia River between high and low tides.

Key Concepts

Unifying Concepts and Processes

* Evidence, models, and explanation
* Change, constancy, and measurement

Science as Inquiry

* Abilities necessary to do scientific inquiry
* Understanding about scientific inquiry

Physical Science

* Motions and forces

Earth and Space Science

* Energy in the earth system

Science and Technology

* Abilities of technological design
* Understanding about science and technology

Science in Personal and Social Perspectives

* Natural and human-induced hazards

Objectives

Include clear, measurable statements of what students will be able to do, such as:

* ***Understand*** how tides affect water flow direction, velocity, and salinity levels in rivers
* ***Calculate*** the fluid volume of water flowing through a pipe.
* ***Apply*** this formula to a real-world situation by predict the volume of water flowing through the Columbia River at a pre-determined day, time, and location.
* ***Use real-time or near-real*** salinity data to determine the directional flow of the river.
* ***Use real-time or near-real data*** to determine the velocity of the river at a certain depth.
* ***Apply real-time or near-real data*** data to the original formulate to estimate volumetric flow in the Columbia River.
* ***Communicate*** the results.
* ***Verify*** the results, (if possible).
* ***Explain*** why predicted flow may differ from actual flow.

Materials

* Worksheets, paper and pencil, computers, internet access. If using Windows 7, make sure to use a 32-bit Java enabled browser.

Procedure

1. Part I – Optional Background Information: This worksheet and website can be used to understanding how the moon affects tides in oceans and rivers.

[http://earthsciencelearningcycle.wikispaces.com/file/view/Tides+Worksheet.doc](http://earthsciencelearningcycle.wikispaces.com/file/view/Tides%2BWorksheet.doc)

<http://en.wikipedia.org/wiki/Coquille_River>

1. Part II - Calculate the volume of water flowing through a pipe using the equation for volumetric flow.

Given: The volumetric flow rate is the volume of fluid which passes through a given surface per unit time. It is represented by the equation Q = A\*C, (which is easily remembered using the mnemonic: “Quack”). The volume of fluid is usually represented by the unit Q. The cross-sectional area of a pipe is represented by *A*. Fluid [velocity](http://en.wikipedia.org/wiki/Velocity) is represented by the unit *C*. The radius of the pipe is 2 meters. The velocity of water is 4 meters per second.

* 1. Calculate A, or cross sectional area of the pipe.

Answer: The equation needed is Q = A\*C. The information needed is the cross sectional area of a pipe and the velocity of the water.The cross sectional area of the pipe is similar to the area of a circle. The area of a circle can be determined using this equation: Acircle = πr2. Rounding π to three, A = 3 \* (2)2. Area = 12 m2.

* 1. Calculate C, or volumetric flow through a pipe.

Answer: The cross-sectional surface area of the pipe (A ) is 12 m. From the paragraph above, the velocity (C) of water is 4 m/s. Inserting these factors into the equation

Q = A\*C…

Q = (12 m2) \* (4 m/s) = 48 m3/s.

Answer: Generally cubic flow is measured in cubic meters per second. If the units are correct in an equation, it is a good indication that the calculation is correct.

* 1. Verify the answer.
	2. If pipe was only half filled with water, what would be the flow rate?

Answer: 48 m3/s divided by 2 = 24 m3/s.

1. Part III - Apply this equation to a real-world situation by predict the volume of water flowing through the inlet of the river at that given point. Remind students that according to the equation Q = A\*C, volumetric flow rate in a pipe can be determined by multiplying the cross sectional area with velocity.
	1. Determine the direction of the velocity. To determine if velocity of the river is negative of positive, we need to find out what direction the river is flowing. When the seawater flows into the river, velocity is negative. When seawater flows out of the river, velocity is positive. Study the salinity data to determine the directional flow of the river.
		1. Briefly review how tide cycles can affect the directional flow at the inlet of a river. Salinity data can be used as an indication of the tide cycle. Study the near-real salinity data by refreshing the web page, taking note high and low tides. When are the highest salinity levels in the river? Answer: During high tide. When are the lowest salinity levels? Answer: During low tide.
		2. When is salt water flowing into the river? When there is a transition from low to high tide. When is the salt water flowing out of the river? When the river is transitioning form high to low tides. When is the velocity the highest in the river? Answer: Between high and low tides.
		3. Go to the following website to understand how the tides affect the salinity of the Columbia River. Click on the link below, and select the “Isolines” tab. From the Region pull-down menu, select “Estuary”. From the Product pull-down menu, select “Salinity PSU 3m” to study the surface salinity levels. The animation can be restarted by refreshing the page.

<http://core02.stccmop.org/datamart/virtualcolumbiariver/forecasts/products?run=2010-196&type=isol&region=estuary&product=sal%2B3&fcast=f22>

* + 1. Does a tidal river exhibit a higher salinity during high tide or low tide?

Answer: During high tide, salt water rushes into a river basin. During low tide, fresh water rushes out of the river into the ocean, creating a freshwater plume in a bay or ocean. Thus, the river has a higher salinity level during high tide.

* + 1. Optional Exercise: Document the date and time of the low and high tides, and mark the general directional flow of the river. Hint: Time is indicated in military time. This exercise is best done more quickly in groups. One person recording information while another person looks at the data and notes aloud the date type of tide, and time of the tide maximum or minimum. The results do not need to be precise.

Sample Chart:

High tide = ebb, or seawater at its maximum height in the Columbia River.

Low tide = flow, or seawater is at its minimum height in the Columbia River.

* 14th High-5/6
* 14th Low- 10/9
* 14th High- 16
* 14th Low- 21
* 15th High - 4
* 15th Low -9
* 15th High- 17/16
* 15th Low -22
* 16th High - 5
* 16th Low - 10/11
* 16th High - 18/17
* 16th Low- 22/23

High tide to low tide – Salt water exiting the river.

Low tide to high tide – Salt water entering the river.

* 1. Determine the velocity of the river. We can determine the velocity of the river near the inlet of the river by studying the velocity map. <http://core02.stccmop.org/datamart/virtualcolumbiariver/forecasts/products?run=2010-196&type=isol&region=estuary&product=vel%2B7&fcast=f22> Set the pull-down menus to Region: Estuary, and Product: Horizontal Velocity (m/s) 7 m. Note: We chose 7 meters of depth to represent the midpoint depth of the river.

Note: One can observe coastal ocean currents by observing the freshwater plumes of water during low tide being pushed north or south along coast in both the salinity and the velocity data sets. Which direction does the coastal current flowing along the Oregon coast? Answer: Generally the current flows in the southward direction in the spring and summer and southward direction in winter and fall. Why? Southwest winds prevalent in fall and winter will cause surface waters to move northward. In spring and summer, winds from the north are prevalent, causing upwelling and southward surface currents.

* + 1. By comparing and contrasting the tidal chart and the velocity data, select a date and time when the water is flowing out of the river at a high velocity. Note: The areas in the velocity map indicate readings that are higher than the sensors can detect. Because we will be using predicted data in the next section, it is best to select a time sequence that will happen in the future. E.g. Velocity peaks can be forecasted by studying predictions. For example, the greatest velocity, or the largest amount of white, appears on 7/16/10 between 5:00 a.m. and 10:00 a.m. (outflow), at 7:00 a.m.
		2. What will the velocity of the river at that time? Answer: Because the data is white in color, the velocity will be greater than 2.25 m/s.
		3. Is the velocity positive or negative? Answer: the velocity is positive because water is flowing out of the river.
	1. Calculate the cross-sectional area of the Columbia River at Tongue Point.
		1. Remind students that according to the equation Q = A\*C, volumetric flow rate in a pipe can be determined by multiplying the cross sectional area with velocity. We have determined C, or the fluid velocity, to be 2.25 meters. We are now seeking A, or the cross-sectional area.
		2. What is the formula for finding the area of a circle? Answer: Acircle = πr2. Because a river can be viewed as half of a pipe, we need to find the depth of the river. Once we find the surface area of the circle, we can divide that amount by 2 to determine the estimated surface area of the river.
		3. Find the depth of the Columbia River. To find the depth between the high and low tides. Go to the Port of Portland website and find the depth of the river at Tongue Point. <http://www.portofportland.com/Nvgt_Rvr_Frcst.aspx> Hint: In the Trip Parameters box, select the “Metric” radio button. Under the Destination pull-down menu, select “inbound”. Enter the time and date selected previously (e.g. 16/7/10 at 7:00 a.m.). Click the “Select” button. (Note: If the Trip Paramters box states the following message, “Some forecasts not available at this time”, select a different date or transition from high tide to low tide to study.)
		4. Roll the mouse over picture of the ship at the Tongue Point set to find the depth of the river. (e.g. on 16/7/10 at 7:00 a.m. the depth of the river was 12.5 m.).
		5. Using the equation Acircle = πr2, calculate the cross sectional area of the Columbia River at Tongue Point. Hint: The cross sectional area of a river is like looking at a cross section of a pipe cut in half. Answer: Acircle = πr2. (3)(12.5)2 = 469 m2. 469/2 = 234.5 m2.
	2. Apply data related to cross-sectional surface area, velocity, and water flow direction original equation to calculate volumetric flow. How do we calculate volumetric flow? Answer: Surface area times times velocity.

Q = A\*C Q = (234.5 m2)(2.25 m/s) = 527.6 m3/s.

* 1. Verify the answer. Are the units correct? Does the calculation look correct? Answer: Generally cubic flow is measured in cubic meters per second. If the units are correct in an equation, it is a good indication that the calculation is correct.
1. Part IV: Evaluating the results. Explain why predicted flow will differ from actual flow.

This is a simplified example of fluid dynamics. In reality, fluid dynamics is complex. This equation is not taking into account numerous factors including the actual topography of the river which changes surface area, turbulence, seawater density, and varying rates of velocity within the river. Seawater is denser, thus it will stay toward the bottom of the river and flow more slowly, causing variability between surface and bottom flow velocity, seen as water sloshing more than flowing.

Assessment

**Performance—**Were the students able to calculate the volume of the pipe? Were the students able to understand how tides affect the salinity in tidal rivers? Were the students able to determine the maximum velocity of the river between a future high and low tide? Were the students able to determine the depth of the river? Were the students able to estimate the cross-sectional area of the river? Were the students able to determine the volumetric flow of the river? Did the students participate in the question and answer sessions?

1. **Product—**Were the students able to use online resources to calculate the volume of water flowing through the Columbia River?

Additional Resources

Other resources helpful in determining the dimensions of rivers and river inlets:

* Google Earth and associated Oceans plugin.
* Topographical maps housed at local public libraries or university libraries.
* Extension activity: Students can determine the depth of a river.

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