Activity: **Do as the Romans: Construct an Aqueduct!**

GRADE LEVELS: 6-8

SUMMARY:

Aqueducts are one of the wonders of the Roman Empire. These graceful structures are not only majestic, but are engineering marvels that survive to this day. In this activity, students work with specified materials to create aqueduct components that will transport 2 liters of water across a short distance in their classroom. The goal is to build an aqueduct that will supply Aqueductis, a Roman city, with clean water for private homes, public baths, and glorious fountains.

By introducing various ideas and themes from the Social Studies curriculum on Ancient Rome and by an additional modeling project this could become a favorite interdisciplinary activity for middle schoolers.

LEVEL OF DIFFICULTY [1 = Least Difficult: 5 = Most Difficult]

4 difficult

TIME REQUIRED

Varies. Could take up to four 50-minute classes (including introductory lesson about Rome, demonstrations, project, and post-discussion/presentation).

COST

$15-$20. Use of old paint buckets, soda bottles, and scrap wood keeps cost down.

STANDARDS:

5.1 Describe and explain parts of a structure (e.g. foundation, flooring, decking, wall, roofing systems)

6.1 Identify and compare examples of transportation systems and devices that operate on each of the following: land, air, sea, and space.

6.2 Given a transportation problem, explain a possible solution using the universal systems model.

6.3 Identify and describe three subsystems of a transportation vehicle (structural, propulsion, and control)

WHAT WILL THE STUDENTS LEARN?

History of the Roman Empire

Building techniques that were used by the Romans.

Creative design methods.

BACKGROUND INFORMATION:

An aqueduct is a pipeline specifically built to transport water.

A chorobate is a surveying instrument that was used by engineers when building an aqueduct. It is used to determine the profile of the land in order to determine where the water needs to flow to reach the city.

Different elements can be built along an aqueduct such as a covered trench, tunnel, pressurized pipe, wall, or arcade.

RESOURCES:

Macaulay, David. City: A Story of Roman Planning and Construction. Houghton Mifflin Company, Boston. 1974.

www.inforoma.it/aqueduct.htm - good background information on aqueducts

www.crystalinks.com/romeaqueducts.html - some pictures and information on how aqueducts are used

www.culture.fr/culture/arcnat/vienne/en/aqueduc.htm - provides a wide range of information on aqueducts

MATERIALS:

Thin plastic drop cloth

Empty 2-liter soda bottle and cap

Bucket

Duct tape

Clear vinyl tubing (3/8" outside diameter)

Cardboard

2-3 tables

Chair

Blocks or books

2 liters water

Scissors

Electric drill or screwdriver

PREPARATION:

Assemble materials

Copy worksheets

Drill 3/8" holes in the tops of 2-liter soda bottle caps for the tubing to fit into.

Set up the "course" that the water will be transported through. Such as from a table to a bucket on the floor 5 feet away, with an obstacle of books between them.

DIRECTIONS:

1. Set the mood by telling the students that they are Chief Water Engineer of the Roman Empire and that their job is to build an aqueduct that will supply the Roman city of Aqueductis with clean water to private homes, public baths, and glorious fountains. If they succeed, the citizens of Aqueductis will drink clean water and bathe happily. If they fail, there's no telling what the citizens will do. The best design will be one that uses minimal materials and delivers water continuously with no spills and little leftover water.
2. Assign the "Roman Aqueduct Manual" as homework reading.
3. Log on to the NOVA website, allowing each student to play "Construct a Roman Aqueduct" in the classroom. (www.pbs.org/wgbh/nova/lostempires/roman/aqueduct.html)
4. Describe the challenge to the students and hand out materials.

5. Students must deliver the water from the bottle at point A to the "city" at point C. Neither the sheet plastic or the tubing is self-supporting, therefore the aqueduct must go through the point B, the bottom of the "valley" (the floor).

6. The water flow should go through the plastic tubing from the soda bottle to the bucket on the floor, with lost water represented by unsupported tubing. Water is precious, so any that escapes the system represents a mistake in engineering, construction, or operation.

7. After completion of the challenge, modifications may be made to the course to make it a little harder. For example, a line of blocks can be added across the table perpendicular to the flow as a hurdle or low hill that the water must be delivered over.

INVESTIGATING QUESTIONS:

How did the Roman Empire manage to supply its urban citizens with water?

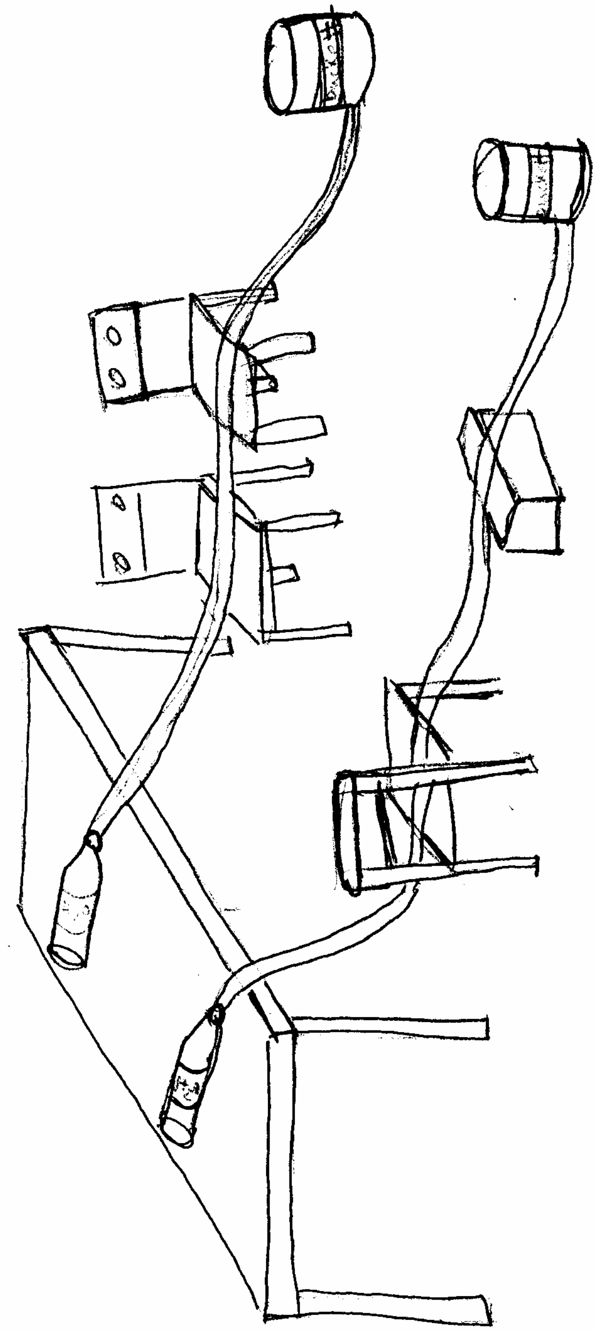
What techniques can be used if mountains and valleys exist between the water source and the city?

How is today's water system similar or different from that of the Romans?

REFERENCES:

From (http://www.pbs.org/wgbh/nova/lostempires/roman/aqueduct.html), the NOVA website "Secrets of Lost Empires," a special five-part NOVA series aired during February 2000, by Dennis Gaffney.

Rubric for Performance Assessment							
Activity Title:	Construct an Aqueduct!						
	1	2	3	4			
Criteria	Beginning	Developing	Proficient	Advanced	Weight (X factor)	Subtotal	
TESTING OF KNOWLEDGE AND CONCEPTS	Does not understand the key concepts of how an aqueduct works.	Understands some of the key concepts of how an aqueduct works.	Able to explain the design of an aqueduct given a drawing showing the landscape between a water source and a city.	Able to make improvements to the design of an aqueduct.			
DESIGN AND CONSTRUCTION OF AN AQUEDUCT	Structure is not very strong. Design does not work.	Structure is not very strong. Design is reasonable.	Structure is stable. Design is good.	Designs and constructs aqueduct with minimal materials.			
OPERATION OF AQUEDUCT	Aqueduct does not work.	Aqueduct works with very little spillage.	Aqueduct works with no spillage.	Aqueduct works with no spillage. Works with optimal speed.			
					Total:		
Teacher Comments:							



Name____________________

Roman Aqueduct Manual

By Dennis Gaffney

Aqueducts are one of the wonders of the Roman Empire. These graceful structures are not only majestic, but are engineering marvels that survive to this day. In "Construct an Aqueduct," you are hired as Chief Water Engineer by the Roman Emperor.

Your job: to build an aqueduct that will supply the Roman city of Aqueductis with clean water to private homes, public baths and glorious fountains. Succeed, and citizens of Aqueductis will drink clean water and bathe happily. Fail, and there's no telling what your countrymen will do.

Mapping the Flow

A water engineer should use a surveying instrument called a chorobates to project a gently sloping line that connects the water source to the city. This way, engineers can figure out where the water needs to flow below ground in tunnels, on the surface in covered trenches or in pressurized pipes, or above ground on walls or arcades.

Every stage of the aqueduct has to be carefully planned to ensure that the water, pulled by gravity, makes its way gradually downhill to the city.

Parts of an Aqueduct

Here are the different elements a Chief Water Engineer can choose to build at any point along an aqueduct:

- Covered Trench
- Tunnel
- Pressurized Pipe
- Wall
- Arcade

Covered Trench

Roughly four of every five miles of Rome's aqueducts run underground, many in covered trenches. Trenches are used when the aqueduct follows the contours of the land. They are quick and easy to build for they require neither the construction of arches nor the burrowing of tunnels.

Romans built underground to hide and protect water from enemies. Even after the Empire expanded, they created a safe buffer around aqueducts, and built underground trenches and tunnels because they protected from the stresses of wind and erosion while underground. Covered trenches and tunnels are also less disruptive to life on the surface than are walls and arcades, which divide neighborhoods and farmers' fields.

Tunnel
Sometimes, aqueduct engineers should carve a tunnel through a mountain rather than build a trench around one. When not too deep, shafts are dug down vertically from above to intersect with the proposed path of the tunnel.

By using shafts, more than one crew can work on a tunnel at a time. The shaft also serves another purpose: Once the tunnel is finished, slaves can crawl down stone steps to clean the tunnel. They can fill buckets with silt or chipped-out calcium deposits left behind from hard water and then haul the buckets out.

Pressurized pipe (inverted siphon)
When faced with a deep valley, Roman engineers should use pressurized pipes that are inverted siphons. Roman water engineers build these rather than arcades because tall arcades are too unstable when built too tall.

With siphons, water travels down one side of the valley in watertight pipes. Water pressure forces water up the other side. Water exits the pipes at nearly the same height as it entered. The pipes are usually built of lead, which is costly, but the material can handle strong water pressure.

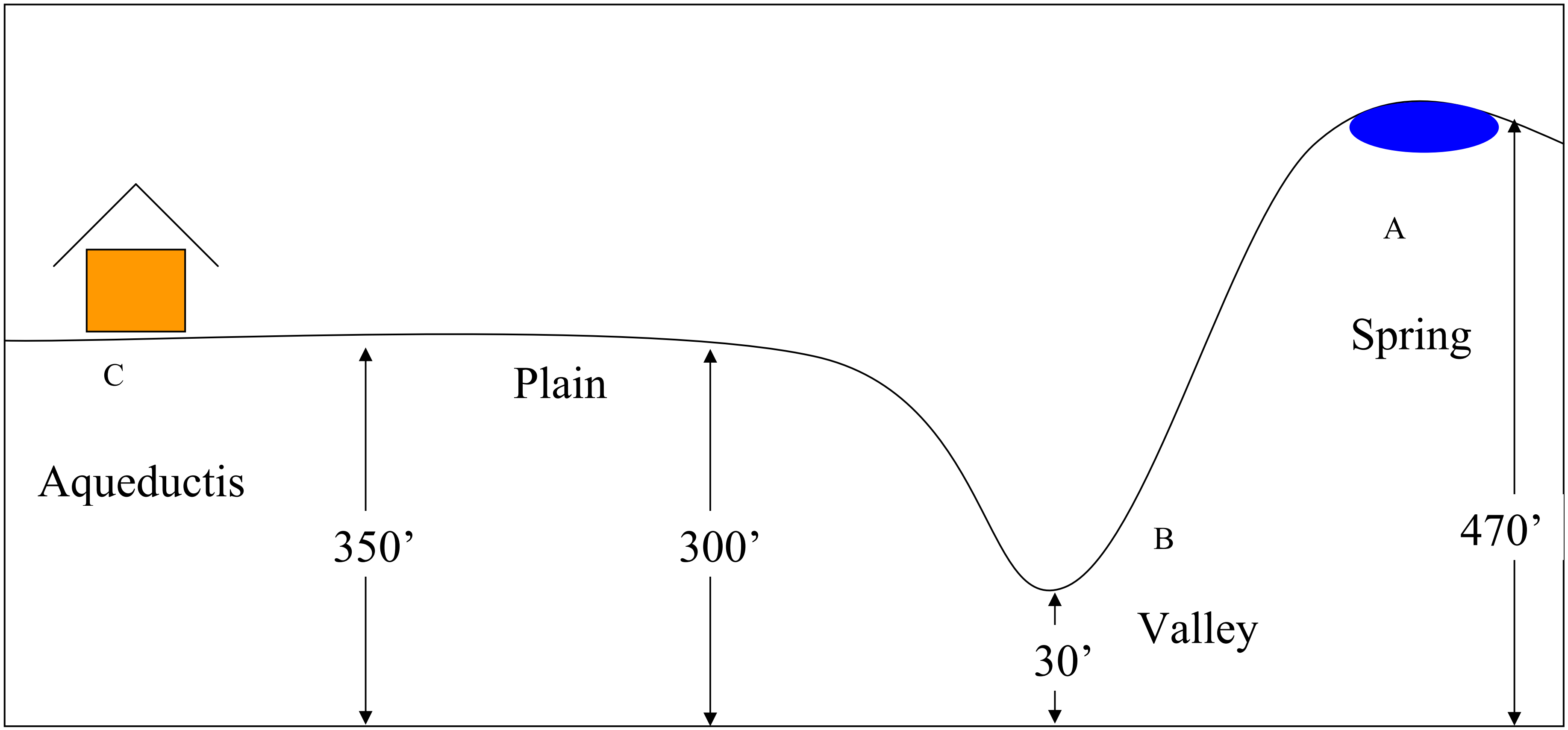
Wall
When aqueduct engineers have to cross shallow depressions in the landscape, they should build the aqueduct on a wall. Simple to construct, walls are easier to build than arcades, although walls can impede the natural flow of water and people.

When engineers need to raise the aqueduct's channel more than approximately five feet above the ground, they should resort to arcades, which allow people and water to move freely beneath them.

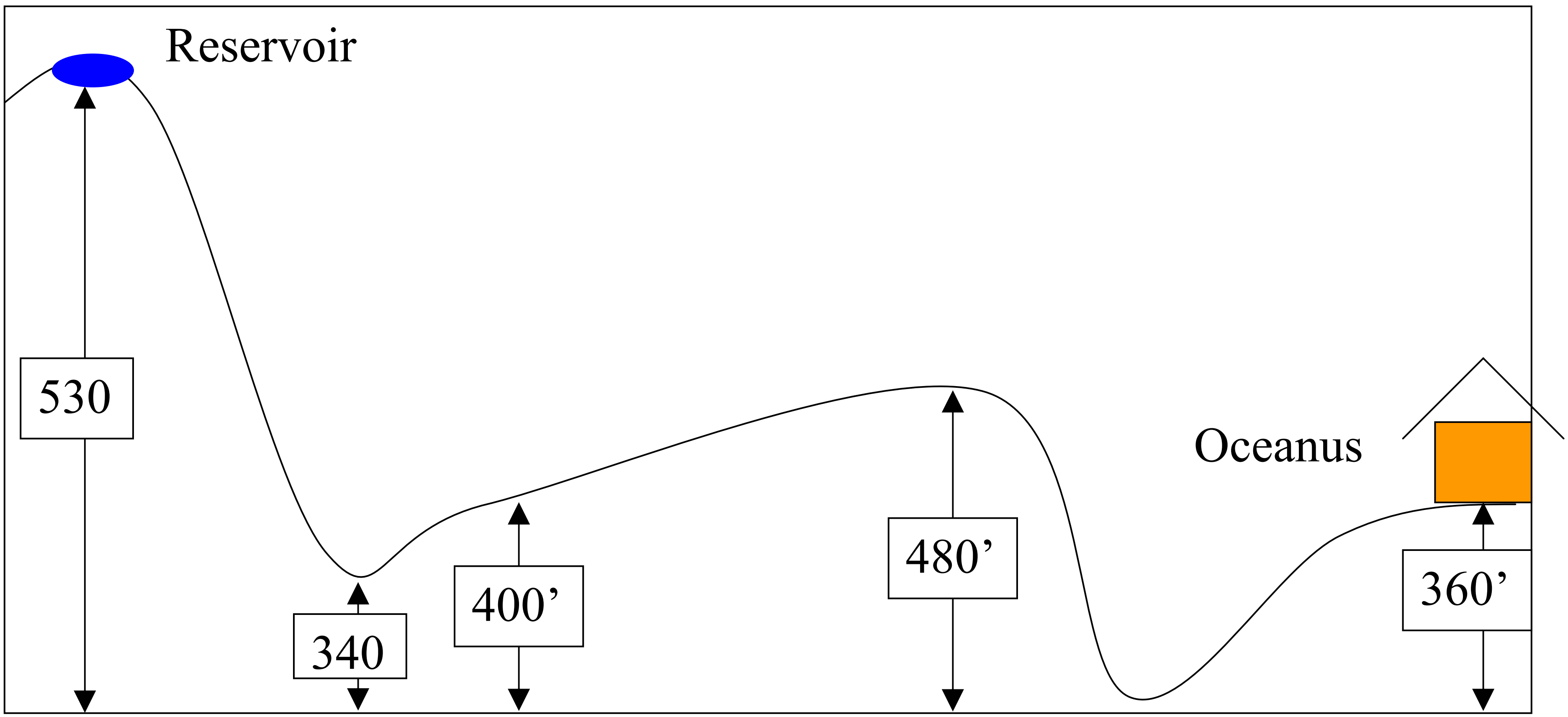
Arcade
In a valley, water engineers should use arcades rather than aqueduct trenches. Arcades, of course, are the bridges built with a series of arches, and one of the grandest monuments of the Empire.

When the aqueduct must flow higher than about five feet, Roman engineers should use an arcade rather than a wall. The arched arcades require less material than walls and don't interfere with the passage of water or people through the environment

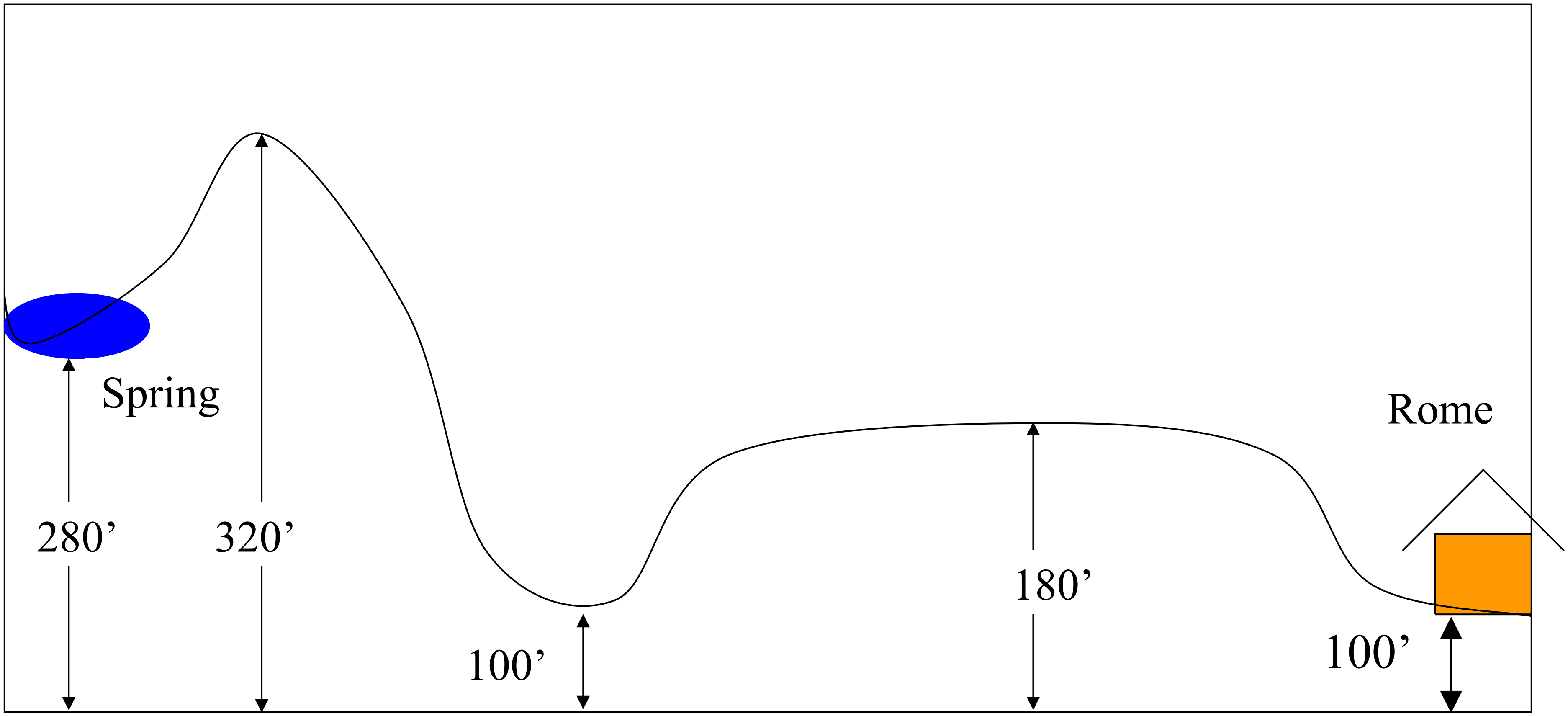
Scenario #1 Aqueductis Is Thirsty!



Scenario #2 Water Delivery to Seaport City of Oceanus

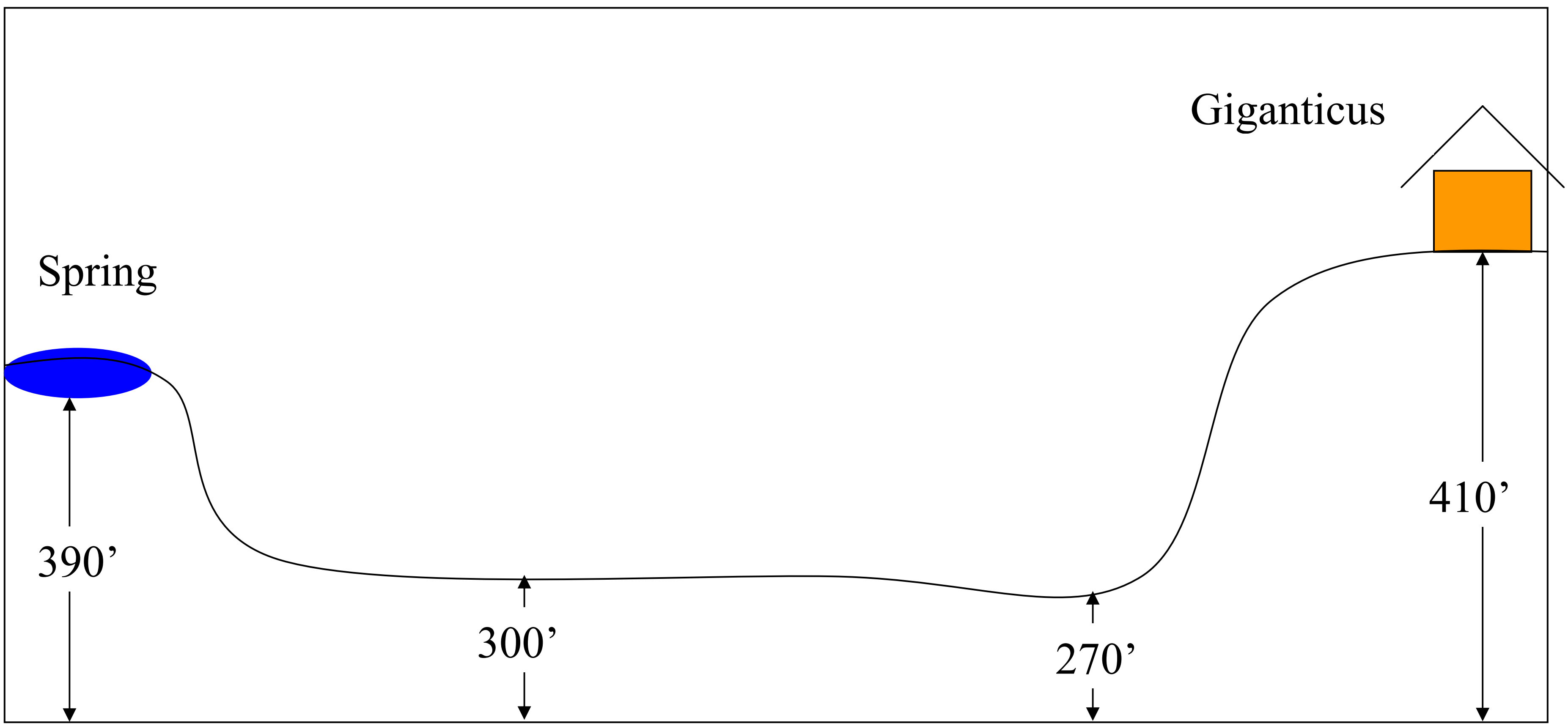


Scenario #3 Hills of Rome



Scenario #4 Giganticus Water Supply.

(this problem cannot be solved using only the elements introduced.)



PreK-12 ENGINEERING

Activity Evaluation Form www.k12engineering.org

Activity Name: ___________________________________

Grade Level the Activity was implemented at: _________

Was this Activity effective at this grade level (if so, why, and if not, why not)?

What were the Activity's strong points?

What were its weak points?

Was the suggested Time Required sufficient (if not, which aspects of the Activity took shorter or longer than expected)**?**

Was the supposed Cost accurate (if not, what were some factors that contributed to either lower or higher costs)**?**

Do you think that the Activity sufficiently represented the listed MA Framework Standards (if not, do you have suggestions that might improve the Activity's relevance)**?**

Was the suggested Preparation sufficient in raising the students' initial familiarity with the Activity's topic (if not, do you have suggestions of steps that might be added here)**?**

If there were any attached Rubrics or Worksheets, were they effective (if not, do you have suggestions for their improvement)**?**

Please return to: CEEO
105 Anderson Hall
Tufts University
Medford, MA 02155