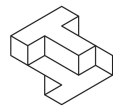


Engineering for Mesopotamia

Design Challenge Learning



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Farmers in ancient Mesopotamia faced many challenges and developed many new technologies to overcome those challenges. In this integrated, multi-day challenge, students will experiment with simple machines and river systems. They will discover the problems facing ancient farmers and design working models to solve the unique problems of ancient Mesopotamia.

Farming in Ancient Mesopotamia: An Ancient Civil Engineering Problem¹

Grade 6-8

Estimated time: 7 sessions (50 minutes)

Student Outcomes:

1. Students will be able to identify the three major obstacles to farming along the Tigris and Euphrates Rivers.
2. Students will be able to build and develop a working model that solves the three major farming obstacles of ancient Mesopotamia.
3. Students will be able to explain design considerations based on science concepts related to rivers as dynamic systems, and simple machines.
4. Students will be able to utilize the three step design process to meet an engineering challenge.

Next Generation Science Standards

Grade 6-8: *Engineering Design* MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4; *Physical Science* MS-PS3-5, *Earth and Space Science* MS-ESS2-2

Common Core Language Arts-Speaking and Listening

Grade 6: SL.6.1b-d, SL.6.4

Grade 7: SL.7.1b-d, SL.7.4

Grade 8: SL.8.1b-d, SL.8.4

History-Social Science Content Standards for California

Grade 6-8: *Chronological and Spatial Thinking* 1-2; *Historical Interpretation* 1-2, 6

Grade 6: *Egypt and Mesopotamia* 6.2.1-2

Vocabulary:

Familiarity with these terms and concepts will enhance students' experience in the activities.

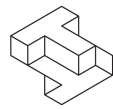
Physical Science (Sessions 1 and 3)

- Elastic Potential Energy: Potential energy due to tension – either stretch (rubber bands, etc.) or compression (springs, etc.).
- Energy: The ability to do work. Appears in many forms, most of which are ultimately derived from the sun or from radioactivity.
- Force: An influence on a body or system, causing or tending to cause a change in movement or shape. A push or a pull.
- Friction: Forces resisting motion between one set of molecules and another due to electrical attraction and repulsion, usually between two solid surfaces; static before motion starts and kinetic during motion. *Note that this only depends on vertical displacement and not the path taken to get there.*
- Gravitational Potential Energy: Potential energy due to elevated position.

¹ A design challenge unit by Alie Victorine, Windmill Springs Elementary School, San Jose, CA.

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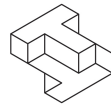
- Inertia: The tendency of matter to remain at rest if at rest, or if moving, to keep moving in the same direction, unless affected by an outside (or unbalanced) force.
- Kinetic Energy (KE): Energy of motion.
- Mass: The amount of matter that is contained by an object.
- Mechanical Energy: Energy possessed by an object due to its motion or its stored energy of position. Mechanical energy can be either kinetic energy (energy of motion) or potential energy (stored energy of position).
- Momentum: The quantity of motion of a moving object, equal to the product of its mass and its velocity.
- Newton's law of Conservation of Energy: Energy cannot be created or destroyed; it may be transformed from one form into another, or transferred from one place to another, but the total amount of energy never changes.
- Newton's Laws of Motion:
 - 1st Law (Law of Inertia): An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.
 - 2nd Law: When an unbalanced force acts on a body, it is accelerated in the direction of the force; $F=ma$.
 - 3rd Law: Forces always occur in pairs. If object A exerts a force, F , on object B, object B exerts an equal and opposite force, $-F$, on object A. Or "Every action has an equal and opposite reaction."
- Potential Energy (PE): Energy of position; energy that is stored and held in readiness.
- Simple Machine: Any of the basic mechanical devices for altering the magnitude or direction of a force.
- Torsion: The twisting of an object due to an applied torque (the tendency of a force to rotate an object about an axis).

Earth Science (Session 2)

- Braiding: A network of small channels separated by small temporary "islands" called braid bars.
- Delta: A low-lying plain or landform formed at the mouth of a river through the deposit of mud, silt, and gravel.
- Deposition: Sediment that comes to rest in a stream channel after being transported by water.
- Erosion: Material (sediment) that comes off of a streambed or bank and is transported by the water in a stream. Caused by the energy of the river.
 - Abrasion/Corrasion: An erosion process in which transported sediment scours the bed and banks.
 - Attrition: An erosion process in which eroded rocks collide to form smaller and smoother fragments of rock. It does not erode the bed and bank.
 - Corrosion: An erosion process in which rocks dissolve through a chemical process.
 - Headward Erosion: A type of erosion that makes the river longer.
 - Hydraulic Action: An erosion process in which the rock particles from the river bed and banks break away due to the pressure of the water.
 - Lateral Erosion: A type of erosion that makes a river wider.
 - Vertical Erosion: A type of erosion that makes a river channel deeper.
- Estuary: A wide mouth of a river with a mixture of salty and fresh water – brackish water.
- Flood Plain: The flat land of the river valley lying close to the river banks.
- Gorge: Steep-sided river valley which is very narrow and deep.
- Levee: A ridge of sediment deposited naturally alongside a river by overflowing water and flooding.
- Meander: A bend in a river.
- Mouth: The location where the river flows into another body of water such as the sea, or a lake.

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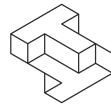
- Ox-bow Lake: A crescent-shaped lake lying alongside a winding river.
- River Cliff: The outside bank of a meander that becomes undercut through erosion processes.
- Runoff: Water running off the land after a precipitation event.
- Slip-off Slope: The gentle slope of the inside of a meander where deposition takes place.
- Stream banks: The sides of a stream holding water inside the channel.
- Streamflow: Water collecting in a stream originating from rain, surface runoff, or groundwater.
- Transportation: Loosened material overcomes the force of friction and moves down the river.
 - Suspension/Suspended Load: A type of transportation that occurs when turbulence lifts fine particles of material and transports it down the river.
 - Solution/Solution Load: A type of transportation in which material is dissolved and carried by the river.
 - Saltation: A type of transportation that occurs when materials that are too heavy to be suspended bounce along the river bed.
 - Traction: A type of transportation that occurs when boulders and other large materials are rolled along the river bed.

History and Social Science (Session 3)

- Agricultural: Relating to or used in a promoting agriculture or farming.
- Agricultural Revolution: A period of transition from the pre-agricultural period characterized by a Paleolithic diet, into an agricultural period characterized by a diet of cultivated foods.
- Dikes: A barrier constructed to contain the flow of water.
- City-states: A city that with its surrounding territory forms an independent state.
- Tigris River: An Asian river; a tributary of the Euphrates River.
- Euphrates River: A river in southwestern Asia; flows into the Persian Gulf; was important to in the development of several great civilizations in ancient Mesopotamia.
- Famine: A severe shortage of food (as through crop failure) resulting in a violent hunger, starvation, and death.
- Fertile: Capable of reproducing.
- Irrigation: The watering of land to make it ready for agriculture.
- Mesopotamia: The land between the Tigris and Euphrates; site of several ancient civilizations; part of what is now known as Iraq.
- Fertile Crescent: A geographical area of fertile land in the Middle East stretching in a broad semicircle from the Nile to the Tigris and Euphrates river system.

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Basic Project Timeline

Session 1

- Design Challenge #1: Flowing From Here to There. Students explore how to use simple machines to transport fine, dry, material from one container to another.

Session 2

- Inquiry Lesson: Stream Table Explorations. Students are introduced to stream tables (either store bought or class-made). They are given time to explore and observe how river systems change over time.

Session 3

- Design Challenge #2: Two Rivers Ran Through It. Students read about the geography and climate of the Fertile Crescent. Working in teams, students begin to brainstorm solutions for each problem.
- Writing Component: Taking on the role of an ancient civil engineer, students compose an essay in which they identify problems and propose solutions for farming the Fertile Crescent. Included with this is a sketch or diagram of their proposed solution. These are delivered to the King/Queen of the City-State (teacher) for approval prior to building (sessions 4 & 5).

Session 4 & 5

- Design Challenge #2: Two Rivers Ran Through It continues.
- Writing component due prior to building the model.
- Model Building: Students build a working model of a river system that solves the problems of drought during planting season, flood during harvest season, and basic transportation of water to the fields.

Session 6

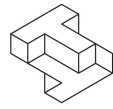
- Design Challenge #2: Two Rivers Ran Through It continues.
- Presentation and Testing: Students explain their design to the class and describe how it solves the challenges presented above. The device is then tested.

Session 7

- Design Challenge #2: Two Rivers Ran Through It continues.
- Wrap-Up and Discussion: Students discuss the different solutions developed within the class. Ancient Mesopotamian solutions to the challenges of farming the Fertile Crescent are investigated and discussed. Compare and contrast class solutions with the solutions found in the historical accounts.
- Evaluation: Students evaluate their final project as well as two other teams utilizing the same rubric as the teacher. They should provide feedback on observed success and propose solutions to failures.

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Resources:

Ancient Mesopotamia

- Ancient Mesopotamia for Kids: A website that provides basic information on Ancient Mesopotamia and its farming and agriculture. There are additional links for information, interactive activities, and online games that relate back to archaeology, history, and framing. <http://mesopotamia.mrdonn.org/agriculture.html>
- Agriculture, Crops, Irrigation in Mesopotamia: A site that provides bulleted information on farming in ancient Mesopotamia. A great resource for interesting information about the subject. <http://factsanddetails.com/world/cat56/sub363/item1513.html#>

Simple Machines

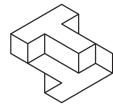
- Simple Machines: Created by the Museum of Science and Industry in Chicago, the website provides an interactive game on Simple Machines. In the game students are tasked with helping a robot retrieve different robot parts by utilizing simple machines to propel, lift, and reach the pieces. The game provides in depth information on mechanical advantage after each level. <http://www.msichicago.org/online-science/simple-machines/activities/simple-machines-1/>
- EdHeads' Simple Machines: An interactive platform that helps identify simple machines around a house and shed. When a simple machine is activated, multiple choice questions encourage kids to further investigate how the simple machine works and why it was used. www.edheads.org/activities/simple-machines/
- Simple Machines: An animated guide to simple machines with explanations on the six basic types and mechanical advantage. www.cosi.org/downloads/activites/simplemachines/sm1.html

Rivers

- Encyclopedic Entry on River: Curated by National Geographic, this encyclopedic entry on rivers provides general information on the science and history of rivers. The website also provides some images of famous rivers. http://education.nationalgeographic.com/education/encyclopedia/river/?ar_a=1
- River Processes: An article by the BBC that explains different erosion processes due to rivers. It includes animations, images, and general information on each process. http://www.bbc.co.uk/schools/gcsebitesize/geography/water_rivers/river_processes_rev1.shtml
- Geology for Kids: A website that provides information on geology in a kid-friendly and accessible form. It includes information on soils, rocks, earth processes, erosion, and water processes. The website has many photos and videos to help with the learning process. <http://www.kidsgeo.com/geology-for-kids/0074-erosion-rivers-lakes-streams.php>

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Design Challenge Process:

The Design Challenge Process is designed so students reinforce their science, mathematics, social studies, and language arts content knowledge, through an open-ended process that results in an original, team-driven solution. Students are expected to take responsibility for assessing their own progress and incorporating peer feedback as they conceptualize and redesign their projects.

The process consists of three interconnected steps:

Conceptualize

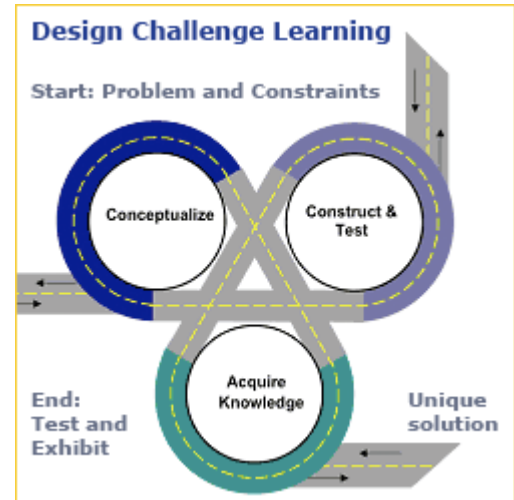
- Identify problem, materials, and constraints
- Brainstorm ideas and possible solutions

Construct and Test

- Select a solution
- Design and construct
- Prototype
- Redesign or modify
- Retest

Acquire Knowledge

- Research
- Share solutions
- Reflect and discuss



Through the try, fail, learn approach, students develop the skills and habits of mind of Silicon Valley innovators: creativity, problem solving, design, collaboration, leadership, risk-taking, perseverance, and learning from failure.

Materials (Comprehensive List):

Materials can be limiting or inspirational to students! Have a wide variety of materials to promote a diversity of solutions. "Recycled items" are really useful: old mouse pads, wood scraps, boxes, cardboard tubes, strawberry baskets, etc.

Materials for Testing:

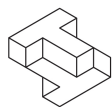
- Large Dishwashing tub (session 1)
- Cookie Sheet (session 1)
- Bean bag pellets, rice, or small gravel (session 1)
- Stream table (session 2-3)
- Sand (session 2-3)
- Wet diatomaceous earth (session 2-3)
- Kitty litter (session 2-3)
- Potting soil (session 2-3)
- Pebbles (session 2-3)
- Gravel (session 2-3)
- Small rocks (session 2-3)
- Buckets and pitchers of water (session 2-3)

Materials for Building (Sessions 1 & 3):

- Cardboard or cardstock
- Plastic caps
- Margarine tubs
- Film canisters
- Plastic/Paper bags
- Cardboard tubing (toilet paper, paper towel, etc.)
- Wheel-like objects
- Cans
- Dowels
- Rubber Bands
- String
- Straws
- Legos or Building Blocks
- Plastic cups (various sizes)
- Plastic Tubing

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Tools:

- Tape
- Hot glue gun/sticks
- Scissors
- Measuring device (ruler, meter stick, etc.)
- Stopwatches
- Protractors

Session 1: Design Challenge #1: Flowing From Here to There (50 minutes)

Materials for testing:

- Large dishwashing tub (river)
- Cookie sheet (field)
- Bean bag pellets, rice, or small light weight gravel

Materials for building:

Materials can be limiting or inspirational to students! Have a wide variety of materials to promote a diversity of solutions. "Recycled items" are really useful: old mouse pads, wood scraps, boxes, cardboard tubes, strawberry baskets, etc.

- Cardboard or cardstock
- Plastic caps
- Margarine tubs
- Film canisters
- Plastic/Paper bags
- Cardboard tubing (toilet paper, paper towel, etc.)
- Wheel-like objects
- Cans
- Dowels
- Rubber Bands
- String
- Straws

Tools:

- Tape
- Hot glue gun/sticks
- Scissors
- Measuring device (ruler, meter stick, etc.)

Research Materials:

Note: Students are not allowed to research ancient civilizations and their solutions.

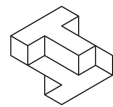
- Books about simple machines
- Posters describing simple machines
- Websites about simple machines
- Handouts on simple machines and the challenge. See "Additional Materials" for suggested handouts.

Setup:

- Resource tables should be arranged around the work space or at the front for: Tools, Building Materials, and Research Materials.
- Student work area should be in an area where spills can be easily cleaned up. If working on carpet, use plastic drop clothes under the work areas and the testing station.
- A large table is needed for the testing area. The only static object in the testing area is the "river;" students may choose the location of the field. However, the instructor may want to angle the river system by placing it on a block to provide a "river" that flows. The "river" is a large dishwashing tub partially filled with bean bag pellets, rice, or small light weight gravel. The "field" is the cookie sheet.

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- Students should be divided into teams of four.

Outline

1. **Introduction:** In this mini-challenge students build a machine to transport water from a river to a field. This introductory challenge will prepare them for the transportation problem they will need to solve in the more extensive model building challenge later on in the week. It allows them to explore the idea of transportation and either use their successful design or redesign for their final model.
2. **Scenario:** Transportation of water from rivers to fields in an easy manner was a problem for early farmers. They certainly didn't want to carry it all by hand. Using only simple machines they created methods or devices to move water.
3. **Challenge:** Create a device that will move the most "water" (bean bag pellets, rice, or small dry solid) from a river, a distance of one meter, and then deposit it in the field.
4. **Constraints:**
 - "Water" may not be moved by hand.
 - The device may not use electricity; it must be human-powered.
 - The "water" must stay clean. No human body parts may enter the river.
 - You may not reposition the river.
 - You have 30 minutes to design and build your device.
 - You will only have three minutes to move all the "water" from the river to the field.
 - You may not spill the "water".
5. **Building:** Teams of four will have 30 minutes to design and build their device. The instructor should go around and ask open ended questions of the teams but should not provide suggestions unless a matter of safety. Provide students with a simple machine reference sheet. *See "Additional Materials" for an example of a Simple Machines Reference Sheet.*
6. **Demonstration and Discussion:** Have each team explain their design decisions and identify the simple machines used in their device. Students should explain their goals in how their device will work and perform. Give each team three minutes to move as much "water" from the river to the field as they can. Remind teams that while fast is good, moving the "water" without spilling it is equally as important. At the end of the testing have students explain what they liked and what can be improved. Questions to guide discussion may include:
 - Are you concentrating on moving the material quickly or carefully?
 - How are you going to prevent spills?
 - What simple machines are you using? How are they helping?
 - Did you do any research to inform your design? How did it help?
 - If you had more time what would you add, change, or do differently?
7. **Reflection:** After the demonstrations and cleanup, students and instructor should decide which designs were successful and in what ways. Discuss what simple machines seemed to work best or were most commonly used and why. Students should be given time to reflect on how they would change their designs.
8. **Evaluation:** Give students an opportunity to evaluate themselves using the same rubric you will use to evaluate them. *See "Additional Materials" for a suggested rubric.*

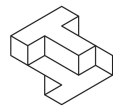
Session 2: Inquiry Lesson: Stream Table Exploration (50 minutes)

Materials:

- Stream table (*See "Additional Materials"*)
- Sand
- Wet diatomaceous earth

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- Kitty Litter
- Potting Soil
- Pebbles
- Gravel
- Small rocks
- Buckets and pitchers of water
- Stopwatch
- Protractor

Setup:

- Students should be divided into teams of four.
- Work outside for easy cleanup.
- Setup a resource table for various types of earth and to replenish water. Pre-bag the necessary amounts of materials for easy pick-up by the teams.
- Each team should have a complete stream table set-up to experiment with.

Outline

1. Introduction: The purpose of this activity is to allow students to observe and discover the changes in a river system over time. As students observe their stream tables in action the instructor will facilitate their learning with questions. Students will also be expected to record their process. See *“Additional Materials”* for a suggested worksheet.
2. The experiment: Students should create their river bed based on the design described in the procedural handout (see *“Additional Materials”*). Once students have completed the initial run of the experiment, they should alter one of the parameters, brainstorm how it will change the system, and then experiment again.
3. Questions to guide student’s initial inquiry:
 - What are some changes you are noticing at the beginning, middle, and end of your river?
 - Has the shape of the river changed? Are there any curves that weren’t there before?
 - What are some possible reasons for the development of curves?
 - What is happening to the sediment? Where is it going? Does this remind you of anything?
 - What shapes do you notice forming at the beginning and end of the river?
 - What is happening to the sides of the river channel? Is it getting deeper or wider?
4. Parameters student’s might change:
 - Rate of flow: What do you think will happen if we change how fast the water flows? How can we change the flow?
 - Stream table height: Are all rivers flat? Are there differences in rivers that run down mountains from those that are on level ground?
 - Obstructions: What if something got in the way of the water?
 - Different sediment: Do you think that all sediment would work the same?
5. Closure: Have students discuss their observations and findings. Use the same questions used during the exploration to help facilitate the discussion. Provide a set of real-world pictures of river systems and label the different parts of the river. Have students compare and contrast the different parts of the river, as well as how the picture of the river compares to their own findings.

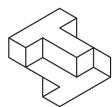
Session 3-7: Design Challenge #2: Two Rivers Ran Through It (50 minutes each)

Materials for testing:

- Stream Tables (See *“Additional Materials”*)
- Sand
- Wet diatomaceous earth
- Kitty Litter
- Potting Soil
- Pebbles
- Gravel
- Small Rocks

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Materials for building:

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- Cardboard or cardstock
- Plastic caps
- Margarine tubs
- Film canisters
- Plastic/Paper bags
- Cardboard tubing (toilet paper, paper towel, etc.)
- Wheel-like objects
- Cans
- Dowels
- Rubber Bands
- String
- Straws
- Legos or Building Blocks
- Plastic cups (various sizes)
- Plastic Tubing

Tools:

- Tape
- Hot glue gun/sticks
- Scissors
- Measuring device (ruler, meter stick, etc.)
- Stopwatch
- Protractor

Research Materials:

Note: Students are not allowed to research ancient civilizations and their solutions.

- Books about simple machines
- Posters describing simple machines
- Websites about simple machines
- Handouts on simple machines, the challenge, and ancient Mesopotamia. See "Additional Materials" for suggested handouts.

Setup:

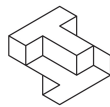
- Resource tables should be arranged around the work space or at the front for: Tools, Building Materials, and Research Materials.
- Student work area should be in an area where spills can be easily cleaned up. If working on carpet, use plastic drop clothes under the work areas and the testing station.
- Students should be divided into teams of four.

Outline

1. Introduction: Taking on the role of an ancient civil engineer, students compose an essay in which they identify problems and propose solutions for farming the Fertile Crescent. Included with this is a sketch or diagram of their proposed solution. Students should be given the opportunity to self-study the geography and climate of the Fertile Crescent (See "Additional Materials"), identify new vocabulary, connect what they are reading to their river experiment (session 2), and identify the problems that ancient farmers faced. After delivering their plans, they are presented with the challenge, discuss constraints and materials, and build their device.
2. The Scenario: You are an ancient Mesopotamian farmer working with other farmers to develop agricultural lands in the Tigris and Euphrates River Valley. You must identify the problems and challenges that your community might face in developing farmland along this mighty river system. You also must be able to explain your ideas of how to overcome these problems to your community so that work can proceed smoothly.

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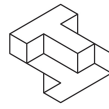
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3. The Challenge: Create a working model of the river, fields, and town that shows how you can overcome all of the problems identified in your proposal.
4. Constraints:
 - The model must include the river, fields, and town, as well as a solution to the identified farming problems.
 - No research may be done on how the Mesopotamians (or any other civilization) conquered the problems.
 - Only simple machines may be used.
 - The use of wood must be limited due to its scarcity.
 - Each group member must participate in the design, construction, and presentation of the models.
 - You may test your model as you work.
5. Building: Teams of four will have about two sessions to design and build their device. The instructor should go around and ask open ended questions of the teams but should not provide suggestions unless a matter of safety. Provide students with reference sheets on simple machines, river system characteristics, and ancient Mesopotamia (See "Additional Materials").
6. Demonstration and Discussion: Students will present from their work stations. They must explain to the class the basic design features of their model and how they solved the identified problems. Starting with the planting/drought season, students should demonstrate how they store and transport water to the fields. They can add small amounts of water to demonstrate this. Next they should demonstrate the yearly flood. *Note: Instructor should use their judgment of how much water to pour. While it would be fair to always add the same amount of water to each model – different materials and platforms will be able to hold or withstand different amounts of water.*
7. Reflection: During session seven, students and instructor should decide which designs were successful and in what ways. Students should be given time to reflect on how they would change their designs. Students should be able to discuss the problems facing the Ancient Mesopotamian farmers and how their solutions attempted to solve those problems. They should take into account how a river behaves based on their explorations with the stream table. Questions to guide student learning may include:
 - What are the three major problems you have to find solutions for?
 - How does your design address the flood, drought, and transportation problems?
 - What will happen if the flood has more water than what you are testing?
 - In the river exploration we did first, there was a lot of sediment carried to the bottom of the river. Do you think that will cause a problem in any way?
 - During a flood what will need protection?
 - How are you planning on transporting water from the river to the field? What are some limitations of your plan?

Engineering for Mesopotamia

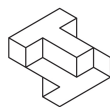
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Additional Materials



HANDOUT: PROJECT OVERVIEW

Flowing From Here to There

SCENARIO:

Transportation of water from rivers to fields in an easy manner was a problem for early farmers. They certainly didn't want to carry it all by hand. Using only simple machines they created methods or devices to move water.

CHALLENGE:

Create a device that will move the most "water" (bean bag pellets, rice, or small dry solid) from the river, a distance of one meter, and then deposit it in the field.

CONSTRAINTS:

- "Water" may not be moved by hand or carried.
- The device may not use electricity; it must be human-powered.
- The "water" must stay clean. No human body parts may enter the river.
- You will only have three minutes to move all the "water" from the river to the field.
- You may not spill the "water".
- You will only have 30 minutes to design and build your device.

MATERIALS AND RESOURCES:

- Various art and construction supplies from the classroom or from home may be utilized. No pre-built machines are allowed.
- You will have access to computers with internet resources and print resources to research design ideas.
- All materials are scarce and difficult to transport. Minimizing the use of your materials is encouraged – only take what you need and only when you need it.

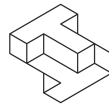
TESTING:

Prior to your demonstration you will need to explain your design decisions and identify all the simple machines utilized in your device. You will also need to give a brief overview of the goals you hope to achieve with your device, and how you hope it will work and perform. Each team will be given three minutes to move as much "water" from the river to the field. While fast is good, moving the "water" without spilling it is equally important.

RESOURCES:


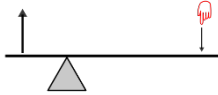
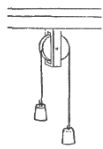
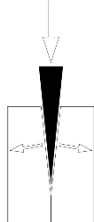

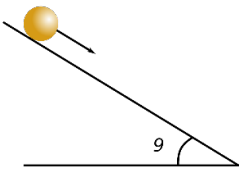
You and your team are allowed to utilize a variety of resources that focus on simple machines. However, you are not allowed to research ancient civilizations and their solutions to irrigation.

- Simple Machines: Practice utilizing simple machines to help a small robot propel, lift, and reach large robot pieces. Don't forget to read about how each simple machine works and how to achieve mechanical advantage with each device. <http://www.msichicago.org/online-science/simple-machines/activities/simple-machines-1/>
- EdHeads' Simple Machines: Try and identify all of the simple machines around a household and take a quick quiz on how specific simple machines work and why we use them. www.edheads.org/activities/simple-machines/
- Simple Machines: A quick animated reference to simple machines and mechanical advantage. <http://www.cosi.org/downloads/activities/simplerachines/sm1.html>



REFERENCE: SIMPLE MACHINES

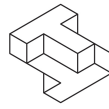
Flowing From Here to There

Type	Definition	Mechanical Advantage	Uses
i Wheel and Axel 	A wheel with a rod, called an axle, through its center lifts or moves loads.	The bigger the wheel, the less force is needed to do the same amount of work.	wagon, bike, car, wheel barrel, gears, pulley
ii Lever 	A stiff bar that rests on a support called a fulcrum which lifts or moves loads.	The more distance you have between the force and the fulcrum, the less force you use to do the same amount of work.	Shovel, seesaw, baseball bat, hammer
iii Pulley 	A simple machine that uses grooved wheels and a rope to raise, lower, or move a load.	Using more rope means covering more distance. Covering more distance means using less force.	Flagpole rig, sailing mast, elevator
iv Wedge 	An object with at least one slanting side ending in a sharp edge; it cuts materials apart.	Allows a force that is applied over a large area to be concentrated upon an edge or smaller area – a concentration of force.	Scissor blades, ax, hoe
v Screw 	An inclined plane wrapped around a pole which holds things together or lifts materials.	Similar to an inclined plane. The smaller the pitch (distance between the threads), the greater the distance of the incline, and the less force you use to do the same amount of work.	Screw, light bulb connection, corkscrew, bottle cap
vi Inclined Plane 	A slanting surface connecting a lower level to a higher level.	The longer the incline, the more distance is used. The more distance you have, the less force you use to do the same amount of work.	Ramp, step, ladder, stairs

RUBRIC

Engineering for Mesopotamia

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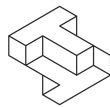
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Flowing From Here to There

Students' Names

Category	4	3	2	1
Function	Device moves all material in under 3 minutes and with little spillage.	Device moves majority of material within 3 minutes and with little spillage.	Device moves some material within 3 minutes. Spillage may be a problem.	Device either does not move material or spills most of it.
Scientific Knowledge	All group members can identify simple machines in their design and articulate mechanical advantage of their construction.	All group members can identify simple machines in their design and the majority can articulate the mechanical advantage of their construction.	Majority of group members can identify simple machines in their design and some can articulate the mechanical advantage of their construction. Explanations by most group members indicate a basic understanding of simple machines used in the construction.	A minority of group members can identify simple machines in their design and articulate the mechanical advantage of their construction. Explanations by several members of the group do not illustrate much understanding of simple machines used in the construction.
Construction Materials	Appropriate materials were selected and creatively modified in ways that made them even better.	Appropriate materials were selected and there was an attempt at creative modification to make them even better.	Appropriate materials were selected.	Inappropriate materials were selected and contributed to a product that performed poorly.

Suggested Improvements (on the back):



Stream Table² *Building Instructions*

The materials used to build the stream table can be found at most hardware stores. The anticipated cost for each stream table built by these specifications is about \$40. The greatest expense for the stream table is the cost of the plastic tub; reducing this cost will significantly reduce the cost of the build.

Materials

- Long, shallow plastic tub with a flat bottom (suggested dimensions: 3 1/2' L x 1 1/3' W x 6" D)
- Two 5 gallon buckets
- Silicon adhesive
- 1/4" Male x 1/4" Female Ball Valve
- Vinyl tubing: 5' of vinyl 1/4" ID (inside diameter), 1/2" OD (outside diameter)
- 1/4" barbed tube fitting with 1/4" male pipe fitting
- 5" length piece of 1-1/2" diameter PVC
- Rubber washer with a 1/2" ID (inside diameter) and at least a 2.5" OD (outside diameter)
- Pipe thread tape
- 12" piece of scrap wood (2x4 or 1x4)

Notes

- Sizes of valves, fittings, and tubing can be adjusted based on product availability. Make sure that all pieces fit together and that the hole drilled into the 5 gallon bucket is appropriately sized.
- It is possible to purchase tee barbed tube fittings with threaded pipe connections. Utilize this style to reduce the amount of water reserve set-ups by half. Be aware that teams will need to coordinate their tests.
- Purchasing containers with snap-tight lids will allow you to easily store the streambeds with the base material in place. Be sure to allow materials to dry completely before replacing lid – suggested drying time is about one week.
- Working outside in spaces with table surfaces long enough to support the stream bed tub/box is ideal. Typically two systems can be easily setup at either end of a standard picnic table.

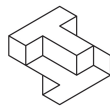
Directions

1. Cut a 3/4" drain hole at the downstream end and on the bottom of the tub. To prevent cracking and warping place a block of wood behind the plastic while drilling. Lightly sand the area around the drain and adhere the washer with the silicon-based adhesive. Secure the washer with tape or a heavy object while the adhesive cures.
2. Drill a 1/4" hole toward the bottom of one of the 5 gallon buckets (water reservoir). Prep the ball valve with thread tape and screw the male-end of the valve into the hole.

² Adapted from Southern Sierra Critical Zone Observatory's "Watersheds and Stream Models," https://eng.ucmerced.edu/czo/E_O_resources/watershed_model.pdf, Accessed 26 May 2015.

Engineering for Mesopotamia

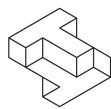
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3. Wrap the male-end of the barb to male tube connector with thread tape and attach to the female-end of the ball valve.
4. Cut a “V notch” into the PVC pipe with a hacksaw. The notch should go about 1/3 of the way down the length of the pipe.
5. Attach the vinyl tubing to the valve via the barbed tube fitting. Elevate the 5 gallon bucket above the plastic tub. Clip a binder clip to the tub – upstream end, opposite of the drain hole drilled in step 1 – and feed the end of the vinyl tubing through the holes on the metal handles so that the vinyl tube is supported above the lip of the container.
6. Place the notched PVC pipe in the stream bed directly under the supported end of the vinyl tubing. The notched portion should be at the top and pointing to the corner of the container diagonally opposite there it has been placed.
7. Use 12” pieces of scrap wood to elevate the upstream end of the stream bed container. Students may manipulate this for different results.
8. The streambed should be placed on table with the drain-hole hanging off the edge. Place the second, unaltered 5 gallon bucket under the drain hole that was drilled into the stream bed container in step one.
9. Fill the bottom with a layer of the base material and any objects that are being utilized. Students may utilize different materials and placement of material as a parameter of the experiment. However, the material should fill a majority of the base of the stream bed container and be about 1” thick. The downstream portion of the container should be left fairly empty particularly around the drain hole. Material should be packed around the notched PVC pipe to ensure it does not fall over or leak too much around the base.
10. Making sure all valves are closed, add water to the reservoir bucket. Slowly open the reservoir valve and allow the water to fill the v-notched PVC pipe. Students may adjust flow rate as one of the parameters of the experiment.



HANDOUT: EXPERIMENT OVERVIEW

Stream Table Exploration

EXPERIMENT:

Determine the changes in river systems overtime due to erosion, transportation, and deposition.

MATERIALS:

- Stream table set-up
- Sand
- Wet diatomaceous earth
- Kitty Litter
- Potting Soil
- Pebbles
- Gravel
- Small Rocks
- Water
- Stopwatch
- Protractor

PROCEDURES:

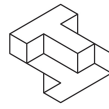
1. Set-up the stream bed components according to the instructor's instructions.
2. Use the block of wood under the upstream portion of your streambed to create an incline.
3. Fill the base of the stream bed with the base material so that it covers a majority of the bottom of the stream bed tub and is about 1" thick. Be careful not to place material on top of or near the drain-hole; you should leave about 3-4 inches of space empty at the base of the stream bed container.
4. Pack the material around the notched PVC pipe so that the water does not cause it to fall over or leak out of the bottom.
5. Make sure that the valve is closed and carefully fill the reservoir container half-way with water (2.5 gallons). Place the other 5 gallon bucket has been replaced under the drain hole.
6. Once everything is set-up begin your experiment by carefully opening the valve to allow the water to fill the notched PVC pipe. You may adjust the valve as needed for your experiment.
7. When the water stops flowing, record your results and cleanup. Carefully repeat steps 2-5 with different materials, different degrees of incline, and different rates of flow. Make sure to only change one parameter at a time. *Note: you may reuse the water by carefully pouring the water from the catch bucket back into the reservoir, making sure no solid material is transferred to the reservoir.*
8. When finished running all experiments make sure to cleanup per the instructor's instructions.

QUESTIONS TO INVESTIGATE:

- What changes take place at the beginning, middle, and end of the river.
- Does the overall shape of the river change overtime? If so, how?
- Does the shape of the beginning and end of the river change over time?
- What happens to the sediment? Where does it go? Does it remind you of anything?
- Does the rate of flow of the water affect how the river's shape, movement of materials, etc.?
- Does the angle of incline change how the river becomes shaped, how materials move, etc.?
- Will obstructions change how a river is formed?
- Do different sediments or base materials change how a river forms?

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DATA SHEET

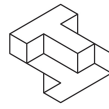
Stream Table Exploration

Students' Names

Material	Incline	Flow Rate	Final Sketch (with labels)	Observations
Sand	10°	Calculate: $\frac{\text{Time}}{\text{Gallons}}$		
		(1/2 turn)		
Sand				
	10°	Calculate: $\frac{\text{Time}}{\text{Gallons}}$		
		(1/2 turn)		

Analogous Models

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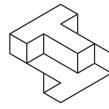
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Material	Incline	Flow	Final Sketch (with labels)	Observations
	10°	Calculate: $\frac{\text{Time}}{\text{Gallons}}$ (1/2 turn)		

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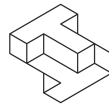
REFERENCE: RIVERS

Stream Table Exploration

Term	Definition	Image
Erosion	Caused by the energy of the river; it can make the bed and banks wider, deeper, and longer.	
Headward Erosion	Makes the river longer. Happens near the source.	
Vertical Erosion	Makes a river channel deeper. More prevalent in the upper stages of a river.	
Lateral Erosion	Makes a river wider. Typically occurs in the middle and lower stages of a river.	
Transportation	Caused by overcoming the force of friction. Material loosened by erosion gets transported along the river.	
Deposition	Happens when a river loses energy and drops eroded materials.	

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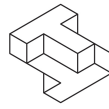
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<p>Gorge</p>	<p>Steep-sided river valley which is very narrow and deep.</p>	 <p>x</p>
<p>Levee</p>	<p>When multiple years of river flooding leaves deposits on the banks in the flood plain.</p>	 <p>xi</p>
<p>Delta</p>	<p>A low-lying plain or landform formed at the mouth of a river through the deposit of mud, silt, and gravel. Very fertile areas with a large amount of vegetation.</p>	 <p>xii</p>
<p>Braiding</p>	<p>Occurring in rivers with high slope and/or large sediment load, consists of a network of small channels separated by small temporary "islands" called braid bars.</p>	 <p>xiii</p>




Analogous Models

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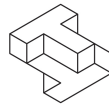
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<p>Meander</p>	<p>A bend in a river. Typically occur in the middle and lower courses where the water is moving slowly.</p>	 <p>xiv</p>
<p>River Cliff</p>	<p>The outside bank of a meander that becomes undercut through erosion processes.</p>	 <p>xv</p>
<p>Slip-off Slope</p>	<p>The gentle slope of the inside of a meander where deposition takes place.</p>	 <p>xvi</p>
<p>Ox-bow Lake</p>	<p>A crescent-shaped lake lying alongside a winding river.</p>	 <p>xvii</p>




Analogous Models

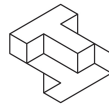
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<p>Mouth</p>	<p>The location where the river flows into another body of water such as the sea, or a lake.</p>	 <p>xviii</p>
<p>Estuary</p>	<p>The wide mouth of a river. A mixture of salty and fresh water – brackish water. Sediment of the river is dropped here.</p>	 <p>xix</p>
<p>Flood Plain</p>	<p>The flat land of the river valley close to the river banks. Typically found in the lower course of a river. The land is fertile and typically used for agriculture and growing crops.</p>	 <p>xx</p>



HANDOUT: PROJECT OVERVIEW

Two Rivers Ran Through It

SCENARIO:

You are an ancient Mesopotamian farmer working with other farmers to develop agricultural lands in the Tigris and Euphrates River Valley. You must identify the problems and challenges that your community might face in developing farmland along this mighty river system. You also must be able to explain your ideas of how to overcome these problems to your community so that work can proceed smoothly.

CHALLENGE:

Create a working model of the river, fields, and town that shows how you can overcome all of the problems identified in your proposal.

CONSTRAINTS:

- The model must include the river, fields, and town, as well as a solution to the identified farming problems.
- No research may be done on how the Mesopotamians (or any other civilization) conquered the problems.
- Only simple machines may be used.
- The use of wood must be limited due to its scarcity.
- Each group member must participate in the design, construction, and presentation of the models.
- You may test your model as you work.

MATERIALS AND RESOURCES:

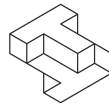
- Various art and construction supplies from the classroom or from home may be utilized. No pre-built machines are allowed.
- You will have access to computers with internet resources and print resources to research design ideas.
- All materials are scarce and difficult to transport. Minimizing the use of your materials is encouraged – only take what you need and only when you need it.

TESTING:

You will present from your work station. You must first present to your community your solution to the farming problem. Starting with the planting/drought season, your team will need to demonstrate how to store and transport water to the fields. Next, you will demonstrate the yearly flood measures and the “rain god” will be responsible for setting the flow rate.

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REFERENCE: MESOPOTAMIA

Two Rivers Ran Through It

Over 5000 years ago, in the region of modern-day Iraq and Kuwait, was an area known as Mesopotamia. The name was given to the region by the Ancient Greeks and meant the “land between rivers”. It is believed that this region is where civilization began. It is where writing and modern mathematics and science were born. This “cradle of civilization” is believed to have occurred because of the fertile land created by the Tigris and Euphrates Rivers.

The two rivers – the Tigris and Euphrates – cut through the dry, flat landscape of the Middle East. Both rivers begin in the mountain ranges to the north and drain into the Persian Gulf. The Tigris and Euphrates pass through mountainous regions with deep gorges and marshy areas of lagoons, reed banks, and mud flats. While the modern Tigris and Euphrates Rivers unite before emptying into the sea, the Rivers of ancient times flowed separately into a sea that stretched much further inland.

The basic climate of the Middle East is hot and dry with long summers and mild winters. While most of the region was inhospitable for crops, the land between the two rivers was a “fertile crescent”. The Tigris and Euphrates are fueled in the north by a system of tributaries, spring snowmelt, and heavy spring rains. Every year in late spring and early summer Mesopotamia would experience flooding as a result of mountain runoff. This flooding deposited silt and created marshy lands with rich, fertile soil. However, the timing and unpredictability of the floods proved hazardous to farming.



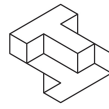
It is difficult to water crops in a region that receives less than 10 inches of annual rainfall and unpredictably floods. The only source of water for Mesopotamia was the two rivers, but transporting the water from the rivers to the fields was an engineering challenge. The development of new technologies that allowed the ancient people to irrigate farmland allowed the city-states to thrive. With better farming came better crops, and with better crops came more food. When societies are easily able to produce more food civilizations develop and prosper.



Map of modern Tigris and Euphrates rivers with the highlighted region of the Fertile Crescent and Mesopotamia. “Map of Fertile Crescent” by Nafsadh.

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RUBRIC

Two Rivers Ran Through It

Students' Names

Category	4	3	2	1
Construction - Care Taken	Creates a working river system that shows a river with head and mouth, city, and farm. All placed in reasonable places.	Creates a working river system that shows a river with head and mouth, city and farm. May not be placed in reasonable places.	Creates a river but may not have an outlet. City and farm are included but may not be in reasonable places.	Creates a river with only a city or a farm not both.
Plan	Attempts to solve all three problems: drought, flood, and transportation of water to fields. Successfully protects both city and field from flooding.	Attempts to solve at least two of the problems: drought, flood, and transportation of water to fields. Successfully protects both city and field from flooding.	Attempts to solve at least one of the problems: drought, flood, and transportation of water to fields. Does not successfully protect both city and field from flooding.	Plan does not attempt to solve any of the problems. No protection from flooding.
Function	Structure functions extraordinarily well, holding up under typical stresses.	Structure functions well, holding up under typical stresses.	Structure functions pretty well, but deteriorates under typical stresses.	Fatal flaws in function with complete failure under typical stresses.
Modification/Testing	Clear evidence of troubleshooting, testing, and refinements.	Some evidence of troubleshooting, and testing and refinements.	Little evidence of troubleshooting testing and refinements.	No evidence of troubleshooting, testing, or refinement.
Scientific Knowledge	Explanations by all group members indicate a clear and accurate understanding of problems faced by early farmers underlying the construction and modifications.	Explanations by all group members indicate a relatively accurate understanding of problems faced by early farmers underlying the construction and modifications.	Explanations by most group members indicate relatively accurate understanding of problems faced by early farmers underlying the construction and modifications.	Explanations by several members of the group do not illustrate much understanding of problems faced by early farmers underlying the construction and modifications.

Suggested Improvements:

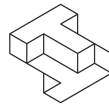


IMAGE CITATIONS

Simple Machines Handout

ⁱ Photo Credit: US National Oceanic and Atmospheric Administration.

- ⁱⁱ "LeverFirstClass" by Iainf 21:31, 9 July 2006 (UTC) - SVG conversion of Image:LeverFirstClass.png. Licensed under CC BY-SA 3.0 via Wikimedia Commons - <http://commons.wikimedia.org/wiki/File:LeverFirstClass.svg#/media/File:LeverFirstClass.svg>
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