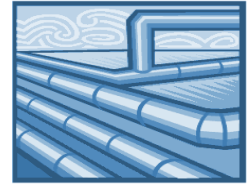




# Pipeline Challenge



Provided by TryEngineering - [www.tryengineering.org](http://www.tryengineering.org)

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## Lesson Focus

Lesson focuses on how engineers develop pipeline systems to transport oil, water, gas, and other materials over very long distances. Lesson provides background about three major pipeline systems worldwide. Students work in teams of "engineers" to develop a pipeline system to transport both a golf ball and ping pong ball across the classroom terrain. Teams develop a plan, draw their pipe plan, anticipate part requirements, build their pipeline, evaluate other plans, and reflect on the activity.

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## Lesson Synopsis

The Pipeline Challenge activity explores how engineers work in a team to solve problems, such as planning a pipeline to deliver water, oil, or gas to a community. Students learn how land and weather, distance, and materials to be transported impact engineering plans. Students work in teams to design a pipeline to transport both a golf ball and ping pong ball from one end of the classroom to another with obstacles and turns. Students develop a plan/drawing, execute their pipeline plan, and evaluate the strategies employed by other student teams.



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## Age Levels

8-18.

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## Objectives

- ✦ Learn how civil engineers approach large scale problem solving.
- ✦ Learn how engineering teams address problem solving.
- ✦ Learn about teamwork and working in groups.

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## Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- ✦ engineering design
- ✦ problem solving
- ✦ teamwork

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## Lesson Activities

Students learn how land and weather, distance, and materials to be transported impact engineering plans. Students work in teams of "engineers" to design a pipeline to transport both a golf ball and ping pong ball from one end of the classroom to another with obstacles and turns. Students develop a plan/drawing, execute their pipeline plan, and evaluate the strategies employed by other student teams.

## Resources/Materials

- ✦ Teacher Resource Documents (attached)
- ✦ Student Worksheets (attached)
- ✦ Student Resource Sheets (attached)

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## Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

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## Internet Connections

- ✦ TryEngineering ([www.tryengineering.org](http://www.tryengineering.org))
- ✦ American Experience: Alaska Pipeline ([www.pbs.org/wgbh/amex/pipeline/sfeature](http://www.pbs.org/wgbh/amex/pipeline/sfeature))
- ✦ West-East Gas Pipeline ([www.petrochina.com.cn/english/gsjz/zyyw\\_04\\_4.htm](http://www.petrochina.com.cn/english/gsjz/zyyw_04_4.htm))
- ✦ ITEA Standards for Technological Literacy: Content for the Study of Technology ([www.iteawww.org/TAA/Publications/STL/STLMainPage.htm](http://www.iteawww.org/TAA/Publications/STL/STLMainPage.htm))
- ✦ McREL Compendium of Standards and Benchmarks ([www.mcrel.org/standards-benchmarks](http://www.mcrel.org/standards-benchmarks))  
A compilation of content standards for K-12 curriculum in both searchable and browsable formats.
- ✦ National Science Education Standards ([www.nsta.org/standards](http://www.nsta.org/standards))

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## Recommended Reading

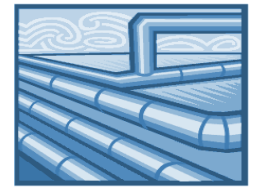
- ✦ Oil & Gas Pipelines in Nontechnical Language (ISBN: 159370058X)
- ✦ Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity, and Repair (ISBN: 0824709640)

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## Optional Writing Activity

- ✦ Write an essay or a paragraph describing how the impact on the environment must be considered when developing a new pipeline system. Give examples of a pipeline in your country that had environmental implications.

# Pipeline Challenge



## For Teachers: Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the National Science Education Standards which were produced by the National Research Council and endorsed by the National Science Teachers Association, and if applicable, also to the International Technology Education Association's Standards for Technological Literacy or the National Council of Teachers of Mathematics' Principals and Standards for School Mathematics.

### ◆ National Science Education Standards Grades K-4 (ages 4 - 9)

#### **CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry

#### **CONTENT STANDARD B: Physical Science**

As a result of the activities, all students should develop an understanding of

- ✦ Position and motion of objects

#### **CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understanding about science and technology
- ✦ Abilities to distinguish between natural objects and objects made by humans

#### **CONTENT STANDARD F: Science in Personal and Social Perspectives**

As a result of activities, all students should develop understanding of

- ✦ Changes in environments
- ✦ Science and technology in local challenges

#### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- ✦ Science as a human endeavor

### ◆ National Science Education Standards Grades 5-8 (ages 10 - 14)

#### **CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry

#### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop an understanding of

- ✦ Motions and forces
- ✦ Transfer of energy

#### **CONTENT STANDARD E: Science and Technology**

As a result of activities in grades 5-8, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

#### **CONTENT STANDARD F: Science in Personal and Social Perspectives**

As a result of activities, all students should develop understanding of

- ✦ Populations, resources, and environments
- ✦ Risks and benefits
- ✦ Science and technology in society

#### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- ✦ History of science

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## For Teachers: Alignment to Curriculum Frameworks (continued)

### ◆National Science Education Standards Grades 9-12 (ages 14-18)

#### **CONTENT STANDARD A: Science as Inquiry**

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry

#### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop understanding of

- ✦ Motions and forces

#### **CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

#### **CONTENT STANDARD F: Science in Personal and Social Perspectives**

As a result of activities, all students should develop understanding of

- ✦ Natural resources
- ✦ Environmental quality
- ✦ Natural and human-induced hazards
- ✦ Science and technology in local, national, and global challenges

#### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- ✦ Historical perspectives

### ◆Standards for Technological Literacy - All Ages

#### **The Nature of Technology**

- ✦ Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

#### **Technology and Society**

- ✦ Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- ✦ Standard 5: Students will develop an understanding of the effects of technology on the environment.

#### **Design**

- ✦ Standard 9: Students will develop an understanding of engineering design.
- ✦ Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

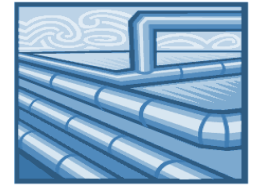
#### **Abilities for a Technological World**

- ✦ Standard 13: Students will develop abilities to assess the impact of products and systems.

#### **The Designed World**

- ✦ Standard 18: Students will develop an understanding of and be able to select and use transportation technologies.
- ✦ Standard 20: Students will develop an understanding of and be able to select and use construction technologies.

# Pipeline Challenge



## For Teachers: Teacher Resources

### ◆ Lesson Goal

Explore engineering problem solving by working in teams to determine a plan for a classroom pipeline. Lesson focuses on how engineers develop pipeline systems to transport oil, water, gas, and other materials over very long distances. Students work in teams of "engineers" to develop a pipeline system to transport both a golf ball and ping pong ball across the classroom terrain. Teams develop a plan, draw their pipe plan, anticipate part requirements, build their pipeline, evaluate other plans, and reflect on the activity.

### ◆ Lesson Objectives

- ✦ Learn how civil engineers approach large scale problem solving.
- ✦ Learn how engineering teams address problem solving.
- ✦ Learn about teamwork and working in groups.

### ◆ Materials

- ✦ Student Resource Sheets and Worksheet
- ✦ One set of materials for each group of students:
  - Golf ball (or similarly sized rubber ball), ping pong ball, PVC (plastic) piping of a diameter to carry the ball selected) including angled pieces, connectors. Enough for each team to build a pipeline that stretches the length of your classroom. As an alternative, cardboard tubes (such as those found in paper towel or toilet paper rolls) can be used with electrical or other strong tape as connectors.

### ◆ Procedure

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. Consider having students visit the American Experience: Alaska Pipeline website and explore how different types of pipe plans are suited for different environmental challenges ([www.pbs.org/wgbh/amex/pipeline/sfeature](http://www.pbs.org/wgbh/amex/pipeline/sfeature)).
3. Divide students into groups of 2-3 students, providing a set of materials per group.
4. Explain that they are engineering teams that have been hired to design and test a pipeline to carry a golf ball and a ping pong ball across your classroom. The successful design will include four angles including one right angle (90 degrees), and a height difference of no more than 18 inches from the beginning to the end of the pipeline. Be sure to identify environmentally protected areas, water, or other hazards in your classroom that the students will have to consider in their plan.
5. Student teams develop the shape of their pipeline on paper, then build their pipeline with materials provided.
6. Each student group evaluates the pipelines developed by other teams, and completes an evaluation/reflection worksheet.



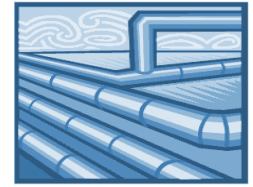
### ◆ Time Needed

Two to four 45 minute sessions

## Pipeline Challenge

Developed by IEEE as part of TryEngineering  
[www.tryengineering.org](http://www.tryengineering.org)

# Pipeline Challenge



## Student Resource Pipeline Projects and Facts

Pipeline transport is a transportation of goods through a pipe. Most commonly, liquid and gases are sent, but pneumatic tubes that transport solid capsules using compressed air have also been used. As for gases and liquids, any chemically stable substance can be sent through a pipeline. Therefore sewage, slurry, and water pipelines exist; but arguably the most important are those transporting oil and natural gas.

### ◆ Baku-Tbilisi-Ceyhan Pipeline

The Baku-Tbilisi-Ceyhan pipeline (sometimes abbreviated as BTC pipeline) transports crude petroleum 1,776 km from the Azeri-Chirag-Guneshli oil field in the Caspian Sea to the Mediterranean Sea. The total length of the



pipeline in Azerbaijan is 440 km long, in Georgia it is 260 km long and in Turkey is 1076 km long. There are 8 pump stations through the pipeline route. The construction of the BTC pipeline was one of the biggest engineering projects of the last decade. It was constructed from 150,000 individual joints of line pipe, each measuring 12 m (39 ft) in length. It has a projected lifespan of 40 years, and when working at normal capacity, beginning in 2009, will transport 1 million barrels (160 000 m<sup>3</sup>) of oil per day. It has a capacity of 10 million barrels (1.6 million m<sup>3</sup>) of oil, which will flow through the pipeline at 2 m (6 ft) per second. The pipeline will supply approximately 1% of global demand.

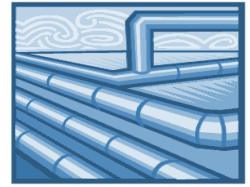
### ◆ Trans-Alaska Pipeline System

The Trans-Alaska Pipeline System is a major U.S. oil pipeline connecting oil fields in northern Alaska to a sea port where the oil can be shipped to the Lower 48 states for refining. The main Trans-Alaska Pipeline runs north to south, almost 800 miles (1,300 km), from the Arctic Ocean at Prudhoe Bay, Alaska to the Gulf of Alaska at Valdez, Alaska, passing near several Alaskan towns. Construction of the pipeline presented significant challenges due to the remoteness of the terrain and the harshness of the environment it had to pass through. Between Arctic Alaska and Valdez, there were three mountain ranges, active fault lines, miles of unstable, boggy ground underlain with frost, and migration paths of caribou and moose. Since its completion in 1977, the pipeline has transported over 15 billion barrels (2.4 km<sup>3</sup>) of oil.

### ◆ West-East Gas Pipeline Project

The West-East Gas Pipeline is a 4,000-kilometers long pipeline, which runs from Lunnan in Xinjiang to Shanghai. The pipeline passes through 66 counties in the 10 provinces in China. The construction of the West-East Gas Pipeline started in 2002 and it was put into operation on 1 October 2004. The pipeline is owned and operated by the Natural Gas and Pipeline Company, subsidiary of PetroChina. The gas will be used for electricity production in the Yangtze River Delta area. There is a plan to replace use of coal by gas in Shanghai by 2010.

# Pipeline Challenge



## Student Worksheet: You are the Engineer!

◆ You are a team of engineers which has to tackle the challenge of developing a pipeline system to transport a golf ball and a ping pong ball from one side of your classroom to the other. But, it's not as simple as it sounds! You need to incorporate four angles in your design, one of which is a right angle (90 degrees) and the difference in height from one end of your pipe to the other can be no more than 18 inches. Your teacher may identify environmentally protected areas, water, or other hazards in your classroom that you'll have to consider in your plan.



### ◆ Planning Steps

1. Review the various Student Reference Sheets.
2. As a team, develop a plan for your pipeline. Draw it in the box below, and include other identifying features of your classroom such as doors, desks, or other areas:

### ◆ Construction Stage

1. Build and test your pipeline using both a golf ball and a ping pong ball.
2. Observe the pipelines constructed by other teams in your classroom

### ◆ Evaluation and Reflection

1. Complete the evaluation sheet and present the work of your team to the class.



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## Student Worksheet: Evaluation/Reflection (continued)

6. Do you think your pipeline design would work if you used it to transport water? Feathers? Butter? Why or why not?

7. Did you find that there were many ways to solve this challenge? If so, what does that tell you about the engineering designs of real pipelines?

8. Do you think you would have been able to create a successful pipeline as easily if you had not been working in a team? What are the advantages of teamwork vs. working alone?

9. How do you think engineers on the Baku-Tbilisi-Ceyhan Pipeline determined that they needed eight pumps to run the length of the project?

10. How do you think engineers working on the Alaskan Pipeline attempted to avoid negative environmental impact in Alaska? Did they succeed?