# DESIGN PROJECTS



# BRIDGES

## GRADE LEVEL

Grades 9-12

## MODELING TIME

2-4 hours

# MATERIALS

- Filament – Approximately 203g

# DESIGN OBJECTIVES

- 3D Printed
- Minimize waste using Flat-Pack Design principles.
- No Fasteners or Adhesives

# DESCRIPTION

Bridges are everywhere and are a vital part of a society's infrastructure  helping assist in the ability to transport people and products to destinations they need to go.

This activity presents a wide range of possibilities for the instructor. The individual components are simple enough for beginners to learn the basics of designing with CAD and the result is a model that can be used to explore the aspects of bridge design. This project is suitable for individuals and teams to eventually design and build their own bridge.

# HISTORY

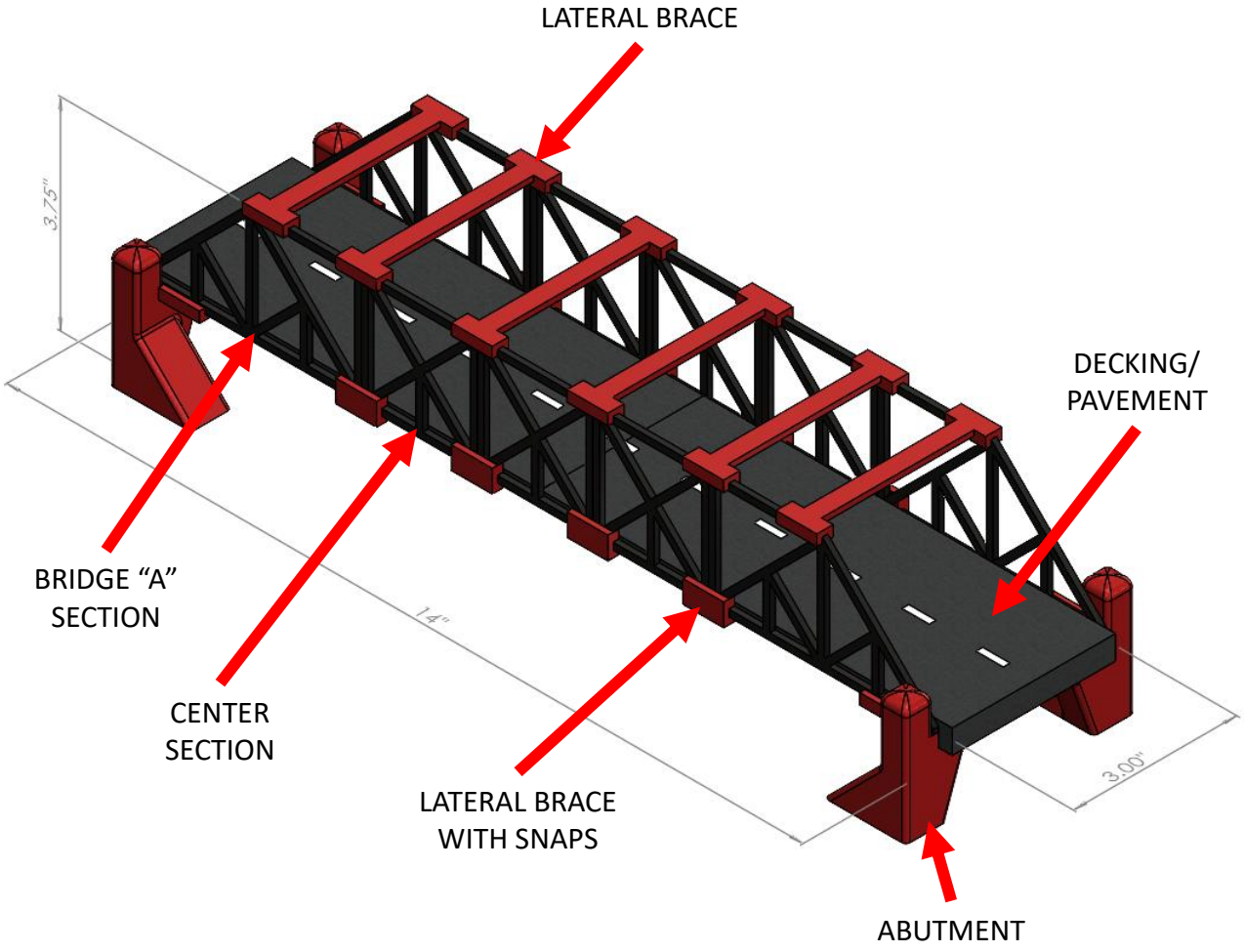
**Pratt Truss –** In Boston, Thomas Pratt and his father Caleb Pratt designed a bridge truss structure that was to become a standard in bridge construction up to World War 2. It was able to span anchor points up to 250ft (76 meters) apart.

**Baltimore Truss –** A Baltimore truss is similar to a Pratt truss design with additional bracing in the lower section to prevent buckling and add strength. The Baltimore truss style bridge is a simple and very strong design often used for supporting trains.

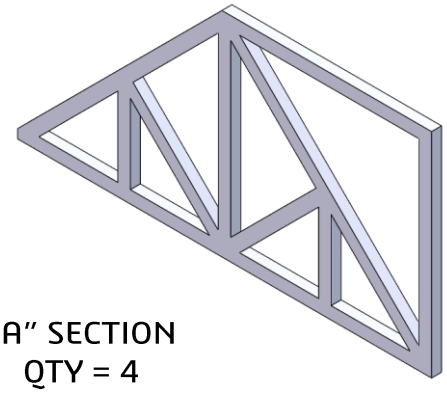
# BRIDGE COMPONENTS



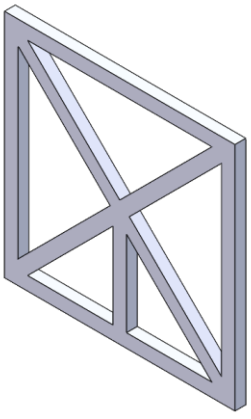
Baltimore Truss



# BRIDGE COMPONENTS

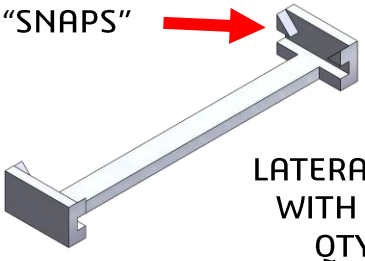


"A" SECTION
QTY = 4

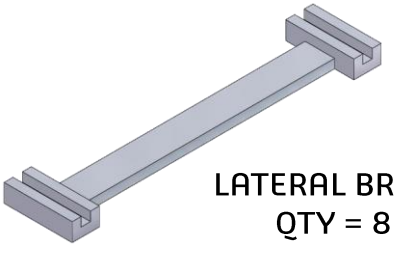


CENTER SECTION
QTY = 6

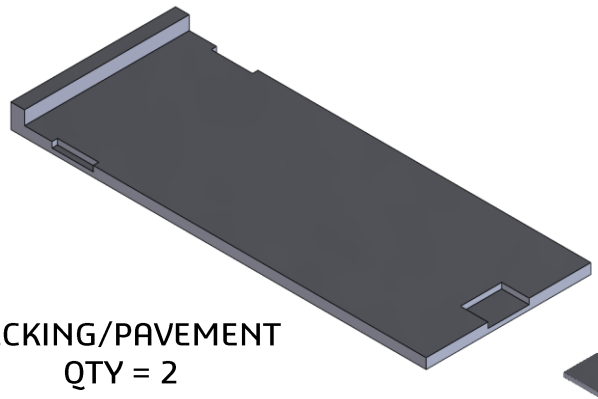
"SNAPS"



LATERAL BRACE
WITH SNAPS
QTY = 4



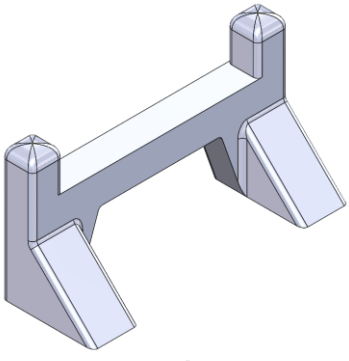
LATERAL BRACE
QTY = 8



DECKING/PAVEMENT
QTY = 2



DECKING
CONNECTOR
QTY = 1



ABUTMENT
QTY = 2

# EDUCATIONAL CONCEPTS

A bridge design and construction project is an excellent way to integrate multiple STEM concepts. Here are some potential teaching approaches:

## SCIENCE

- Discuss properties of materials like tensile strength, compression, elasticity, and their suitability for bridges.
- Test the strength of different 3D printing materials, such as PLA vs. ABS.
- Explain forces acting on a bridge (e.g., tension, compression, shear, and torsion).

## TECHNOLOGY

- Teach students to use 3D modeling for creating their bridge designs.
- Demonstrate how 3D printers work, from slicing software to the actual printing process.
- Discuss additive manufacturing principles and how they differ from traditional methods.
- Emphasize the importance of DFAM, Designing for Additive Manufacturing, by minimizing waste through smart design.

## ENGINEERING

- Compare designs like suspension, arch, truss, and cable-stayed bridges.
- Challenge students to select a design type based on specific constraints (e.g., span length, weight capacity).
- Introduce failure analysis to identify and fix weak points in the design.
- Focus on problem-solving and overcoming design failures.

## MATHEMATICS

- Discuss geometric principles used in bridge design, such as triangles in trusses for stability.
- Calculate angles, lengths, and dimensions for accurate CAD modeling.
- Measure and analyze load capacities of printed models, comparing results to predictions.
- Have students estimate material costs, factoring in 3D printer filament usage.
- Compare budget-friendly designs to more elaborate ones.

# OPTIONAL CHALLENGES

- Assign roles (e.g., design engineer, materials specialist) to mimic real-world engineering teams.
- Divide students into teams. Have each team design a unique bridge and have a competition using the models.

# DISCUSSION STARTERS

- How does adding the decking improve the strength of the bridge?
- Why should the bottom angles of the abutments face inward?
- How long of a span can be achieved in order to support a 10lb weight? (add center sections, with decking or without)
- How does the Baltimore design compare to other bridge designs?

# ASSESSMENT CRITERIA

- **SUSTAINABILITY** – How much waste is generated in the manufacturing process?
- **ASSEMBLY** – With no adhesives or fasteners, does the model hold together on its own?
- **MANUFACTURABILITY** – Do the components fit within the parameters of the 3D printer? Laser cutter?
- **PERFORMANCE** – How long of a span with the bridge?

# ADDITIONAL RESOURCES

**LINK TO DOCUMENTS**

**LINK TO YOUTUBE VIDEO**

**LINK TO STEP-BY-STEP**