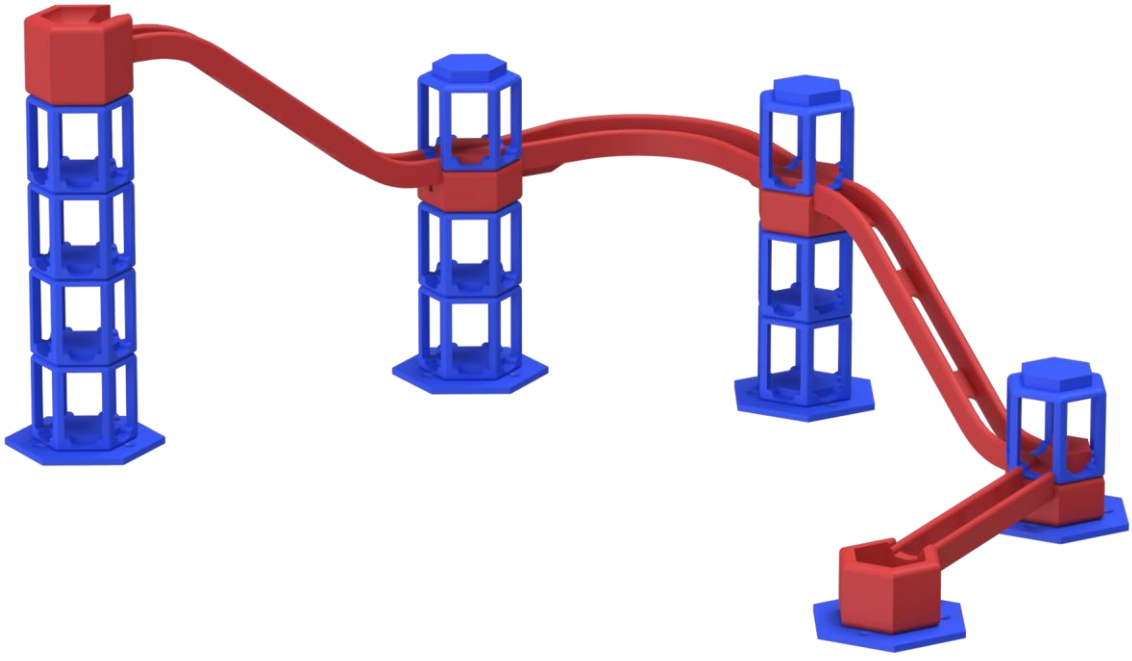
DESIGN PROJECTS



MARBLE RUN

GRADE LEVEL

Grades 9-12

MODELING TIME

8-10 Hours

MATERIALS

- PLA Filament – Approximately 335g
- Marbles – Approximately 0.63in (16mm) diameter
- Plywood (or equivalent material) and screws for mounting (optional)

DESIGN OBJECTIVES

- 3D Printed
- Minimize waste
- No fasteners or adhesives
- Modular design for reusability

DESCRIPTION

Marbles are toys that have inspired countless games and innovations since their inception in ancient civilizations. Today, marble runs are a common outlet for innovation and creativity among students and engineers alike.

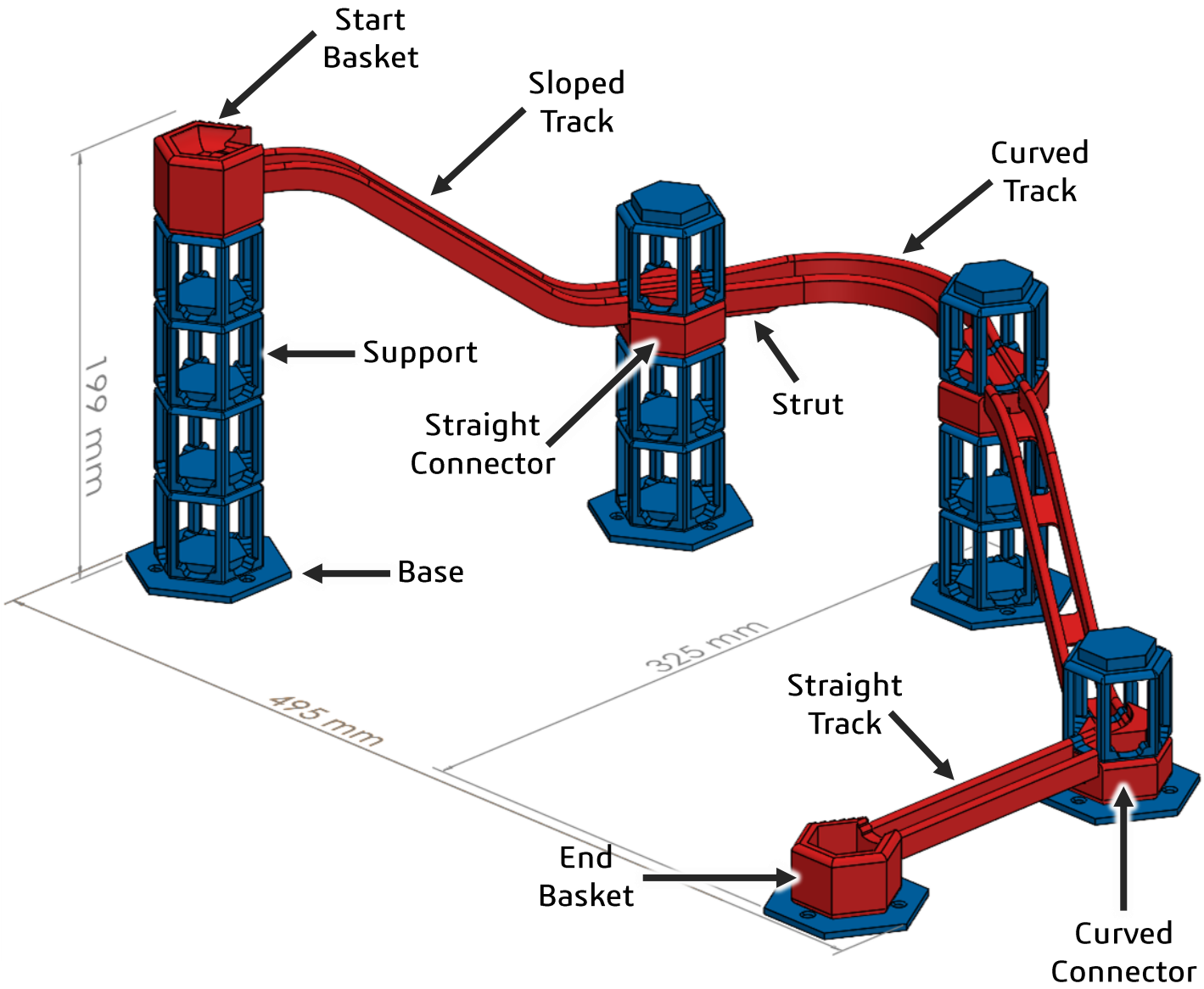
This activity presents a wide range of possibilities for the instructor. The individual components are simple enough for beginners to learn the basics of designing with CAD and provide a valuable exploration of modular design and concepts of kinetic and potential energy. This project is suitable for individuals and teams to design and build their own modular marble runs.

HISTORY

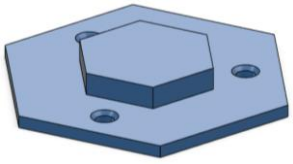
Archaeologists have discovered marble-like objects dating back to 2500 BCE in ancient civilizations across the world. Marbles were prominent in the lives of ancient Romans, Egyptians, Mesopotamians, and Harappans before they were eventually mass-produced starting in the 1870s. Throughout history, marbles were made from various materials and used in countless games to entertain both children and adults.

It was not until the early 1900s that marble racing gained popularity, with events being held across Europe and the United States. Today marble runs are a common outlet for creativity of people of varying age and skill.

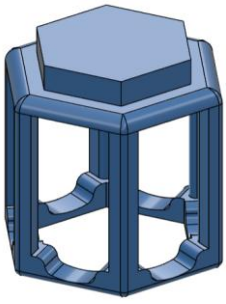
MARBLE RUN COMPONENTS



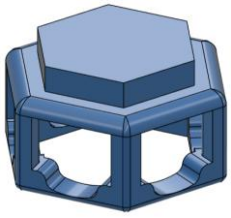
MARBLE RUN COMPONENTS



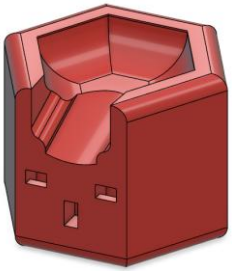
Base Plate



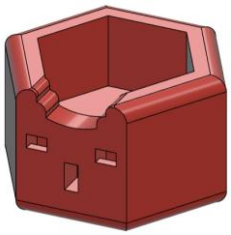
Support



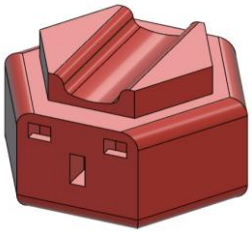
Half Support



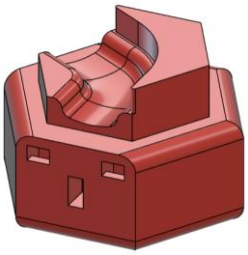
Start Basket



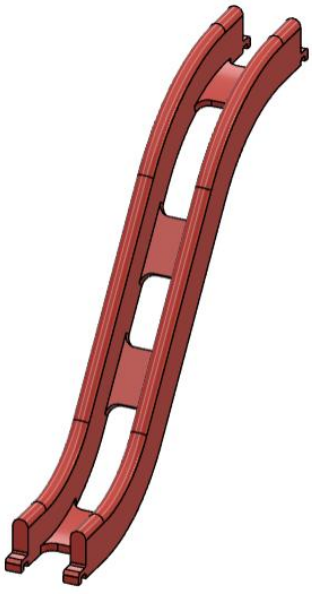
End Basket



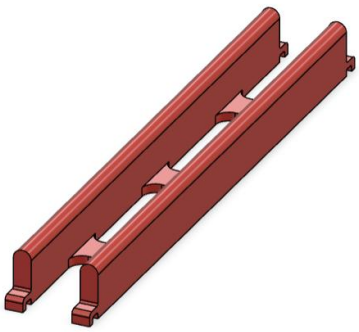
Straight Connector



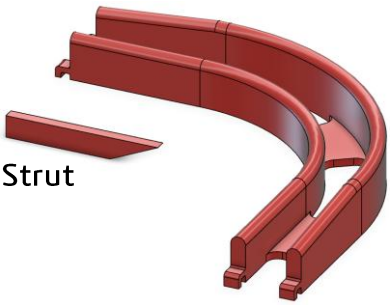
Curved Connector



Sloped Track



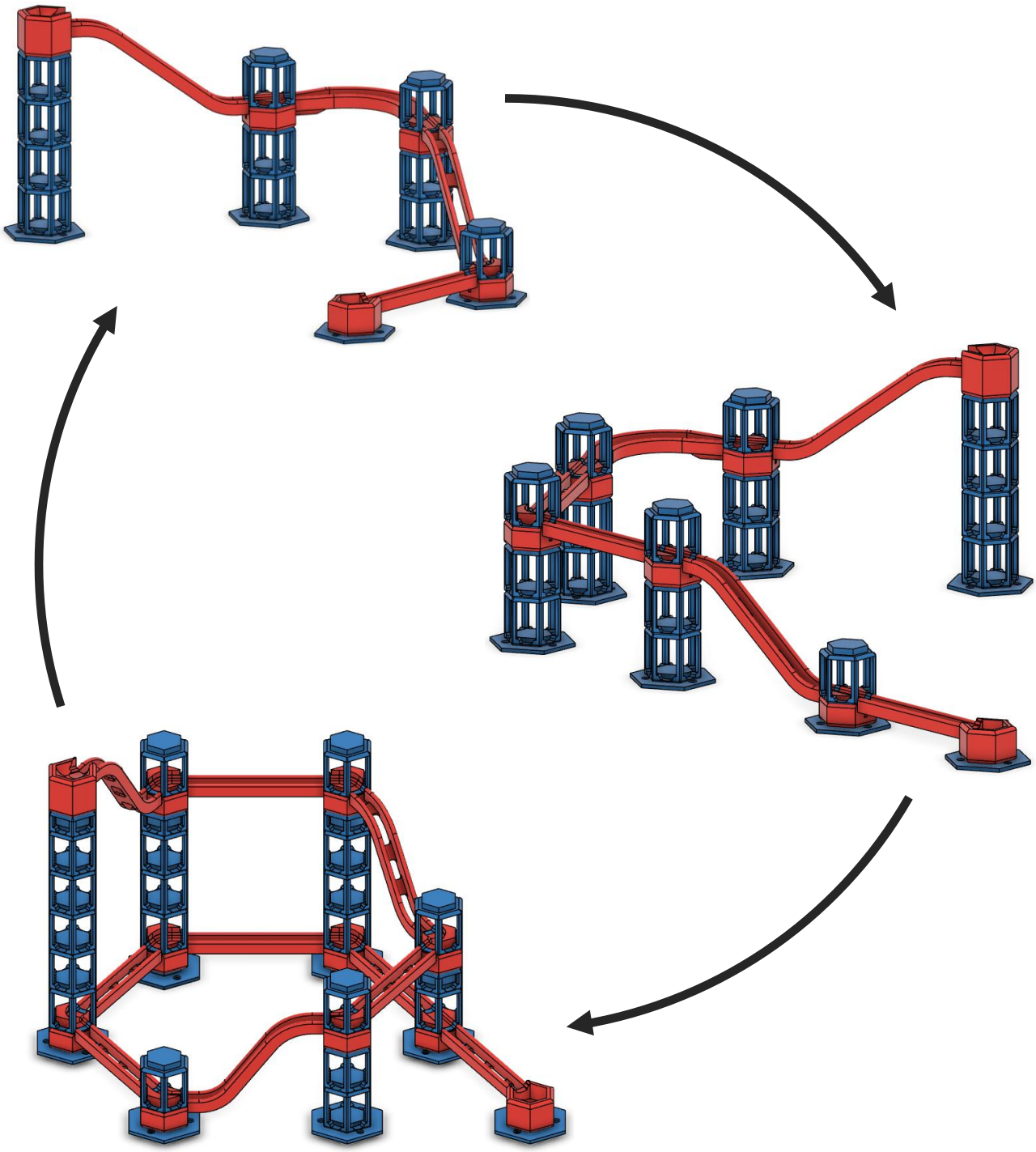
Straight Track



Strut

Curved Track

RECONFIGURABLE DESIGN



EDUCATIONAL CONCEPTS

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

SCIENCE.

- Explore energy transfer: potential energy from gravity converting to kinetic energy and back as the marble traverses the track.
- Discuss how friction affects the marble's movement on long, flat tracks.
- Examine the principles of inertia and how the marble must encounter another force to turn (e.g., banked turns), stop, or speed up.

TECHNOLOGY

- Teach students to use 3D modeling for creating their marble run 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

- Explore a modular design approach to ensure designs are adaptable and reusable – how can a part be designed to be used in the largest number of marble run configurations?
- Discuss structural stability and how to prevent the marble run from falling apart.
- Practice the iterative design process for various marble tracks, track configurations, latching mechanisms, and support designs.

MATHEMATICS

- Calculate track angles, lengths, and heights required for consistent motion.
- Analyze potential and kinetic energy while designing tracks to ensure they work as intended.
- Solve for the velocity of the marble at different parts of the track.
- 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, quality assurance) to mimic real-world engineering teams.
- Divide students into teams. Have each team design a unique marble run and have a competition using the models.

DISCUSSION STARTERS

- How much momentum is required for the marble to traverse various tracks? What causes the need for more or less momentum?
- What additional design considerations are necessary when following a modular design approach?
- Why is modular design useful? When might engineers put extra effort towards modular design?

ASSESSMENT CRITERIA

- **SUSTAINABILITY** – How much waste is generated in the manufacturing process? Can parts be reused?
- **ASSEMBLY** – With no adhesives or fasteners, does the model hold together on its own? Are the tracks easily re-configurable?
- **MANUFACTURABILITY** – Do the components fit within the parameters of the 3D printer? Do the components' designs and orientation minimize support material?
- **PERFORMANCE** – Do the marbles stay on the track? Do they make it to the end of the track?

ADDITIONAL RESOURCES

LINK TO DOCUMENTS

LINK TO YOUTUBE VIDEO

LINK TO STEP-BY-STEP