Rotary Motion

v3.0

Mechanisms & Movement | **Curriculum Packet**

Overview:

In this lesson, students will learn how to create rotary motion using Kid Spark engineering materials. Students will build a simple gear train and observe how it creates rotary motion. Then, students will work as a team to create a custom design that produces rotary motion.

Click here to explore the entire Kid Spark Curriculum Library.

Learning Objectives & NGSS Alignment:

- Define rotary motion.
- Build a gear train and observe how it creates rotary motion.
- Create a custom design that produces rotary motion.

Scientific/Engineering Practice - Asking questions & defining problems

Crosscutting Concept - Cause & effect; mechanism & explanation

Activity Time:
120 Minutes

Targeted Grade Level:
2 - 5

Student Grouping:
Teams of up to 4 students

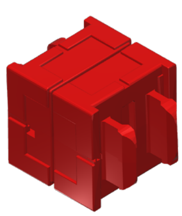
Additional Lesson Materials:
- Teacher Lesson Plan
- Student Engineering Workbook

Kid Spark STEM Lab:
STEM Pathways **or**
Engineering Pathways (w/Spark:bit)

Convergent Learning Activity:

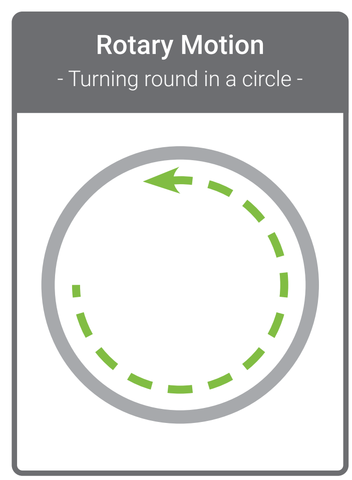
1. Exploring Rotary Motion

Rotary motion is motion that turns round in a circle. There are several Kid Spark engineering materials that can be used to produce rotary motion, including the axle block and the snap-in wheel.



Axle Block

Snap-In Wheel



Instructions:

Step 1: Locate an axle block and a snap-in wheel. Observe how they create rotary motion.

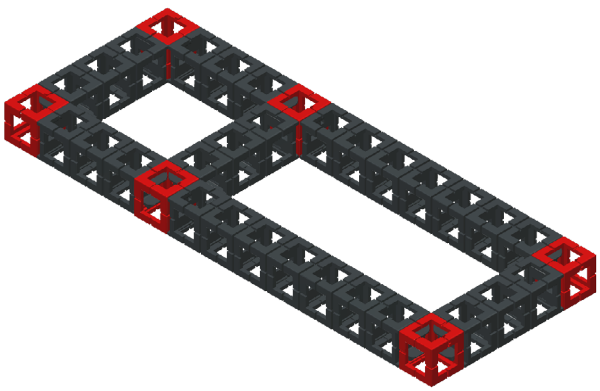
Step 2: Try and locate a few additional engineering materials in the Kid Spark Lab that produce rotary motion.

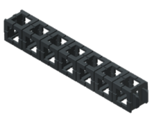
Step 3: Discuss some real-world examples of rotary motion.

Instructions:

Follow the step-by-step instructions to assemble a simple gear train that produces rotary motion.

1



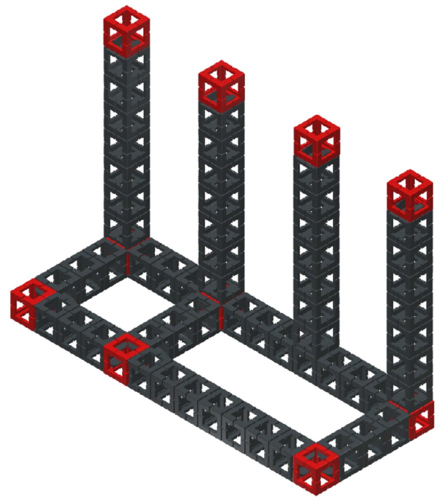


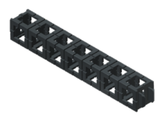
2x
Beams

5x
Half Beams

6x
Blocks

2

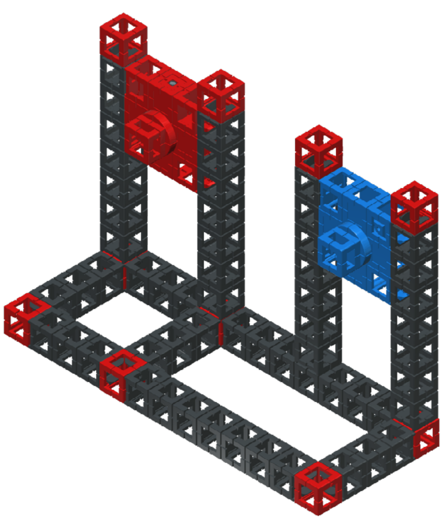


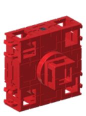


4x
Beams

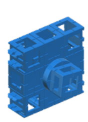
4x
Blocks

3



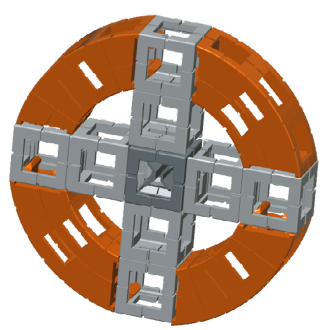


1x
Motor Module

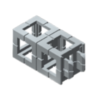


1x
Bearing Module

4



4x
Mini Curved Beams



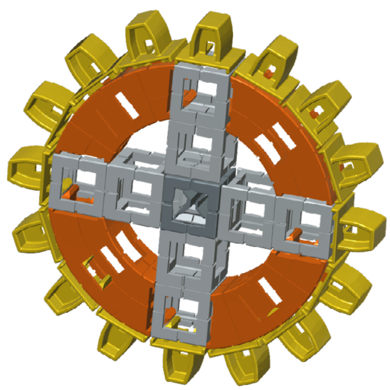
4x
Risers

1x
Single Snap Block

Instructions:

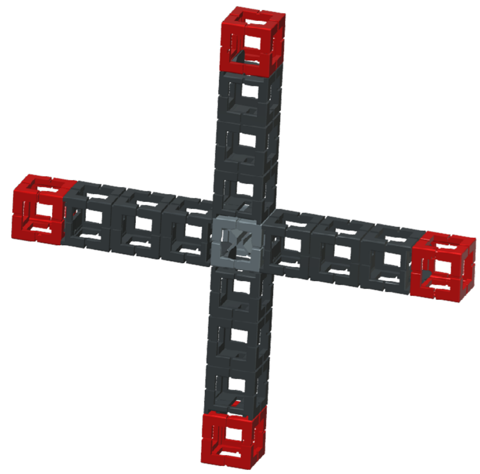
Follow the step-by-step instructions to assemble a simple gear train that produces rotary motion.

5



16x
Gear Teeth

6

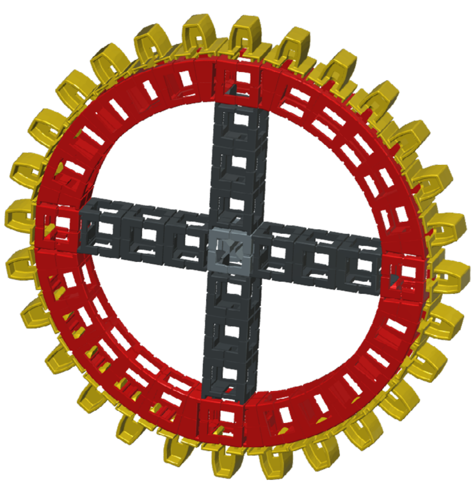


4x
Half Beams

1x
Single Snap Block

4x
Blocks

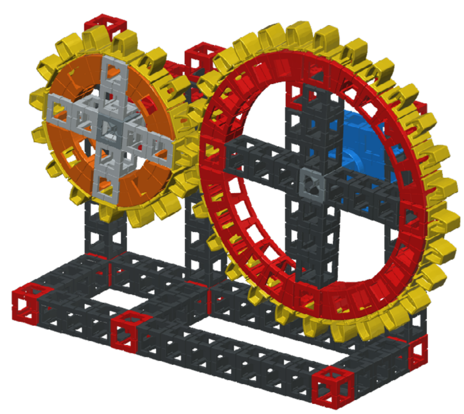
7



4x
Small Curved Beams

28x
Gear Teeth

8

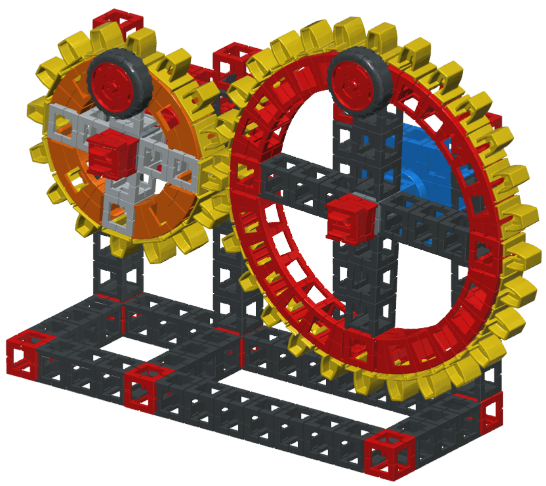


Instructions:
Place the small and large gears on the structure as shown.

Instructions:

Follow the step-by-step instructions to assemble a simple gear train that produces rotary motion.

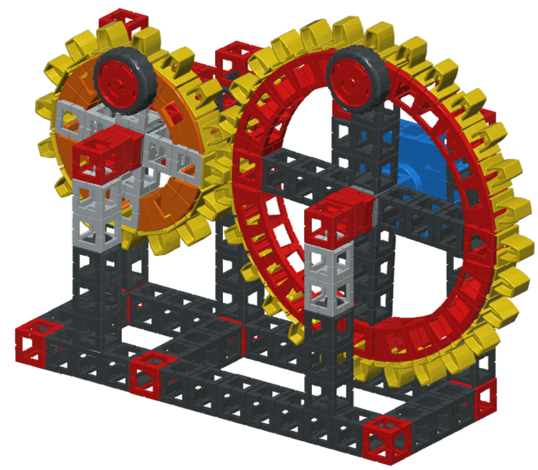
9

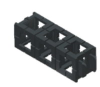


2x
Snap-In Wheels

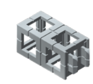
2x
Axle Blocks

10





2x
Half Beams

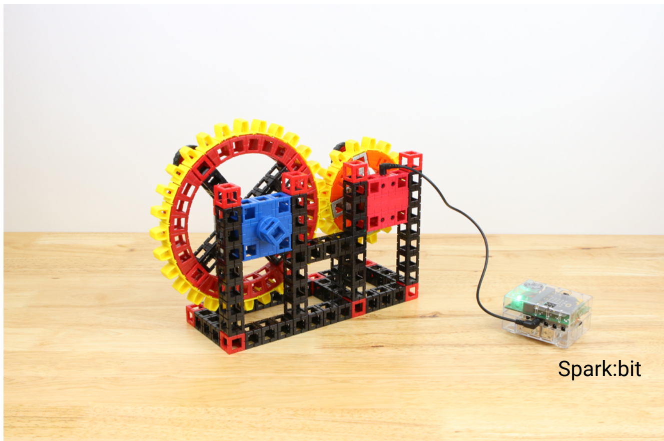


2x
Risers

2x
Blocks

Instructions:

Follow the step-by-step instructions to assemble a simple gear train that produces rotary motion.



Instructions:

Step 1: Connect a Motor Cable to the Motor Module. Connect the opposite end into Output 1 on the Spark:bit.

Step 2: Power on the Spark:bit.

Step 3: Activate Motor Override Mode on the Spark:bit using the switch located next to output 1.

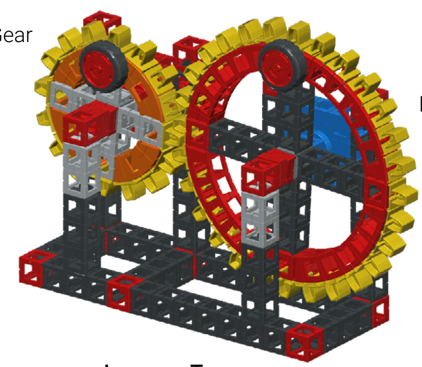
Step 4: Press the A/B buttons on the Spark:bit to activate the gear train.

In this example, a motor module is being used to drive a simple gear train. Look closely at the rotating gears and observe how they are actually rotating in opposite directions. Also, observe how the small gear is rotating faster than the large gear.

The main purpose of a gear train is to increase torque (power) or speed. The arrangement of the small and large gears will determine if the gear train will increase torque or speed.

To increase torque (a twisting force that causes rotation) using a gear train, a motor module should be directly connected to a small gear and used to drive a large gear.

To increase speed using a gear train, a motor module should be directly connected to a large gear and used to drive a small gear.

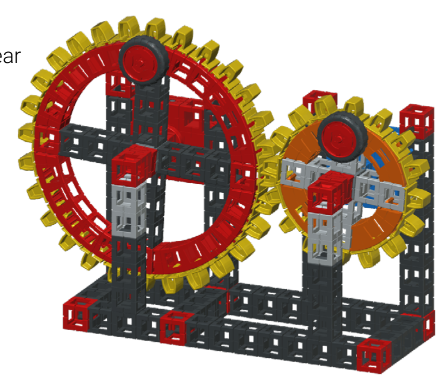


Increase Torque

Instructions:

Step 1: Rearrange the gears so the large gear is connected to the motor module and the small gear is connected to the bearing module.

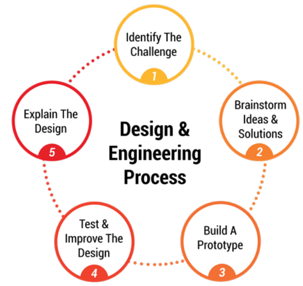
Step 2: Activate the gear train and observe how much faster the small gear is rotating than the large gear. This gear train is now set up to increase speed.



Increase Speed

Divergent Learning Activity:

Scenario:
Kid Spark Engineering is currently accepting proposals for new and creative product inventions or innovations.



Design & Engineering Challenge:
Develop a new product or design that produces rotary motion. See example below.

Specifications/Criteria:

1. Students will work in teams of up to 4 to design and engineer a new product or design that serves a specific purpose. Teams can invent something completely new or improve an already existing product.
2. Teams must work through each step of the Design & Engineering Process to design, prototype, and refine their design. Teams will demonstrate and present their designs to the class when they are finished.
3. The product or design must be powered by the Spark:bit.
4. The design must produce rotary motion.
5. Teams must determine the overall dimensions (length, depth, and height) of the product or design, as well as any detailed specifications that are relevant to the design.
6. With each building component costing $2, determine the total cost of the design.

Example Idea:

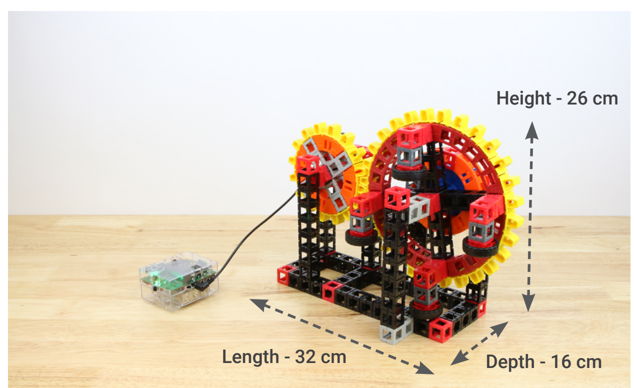
Product Innovation/Invention: Ferris Wheel (4 Chair)

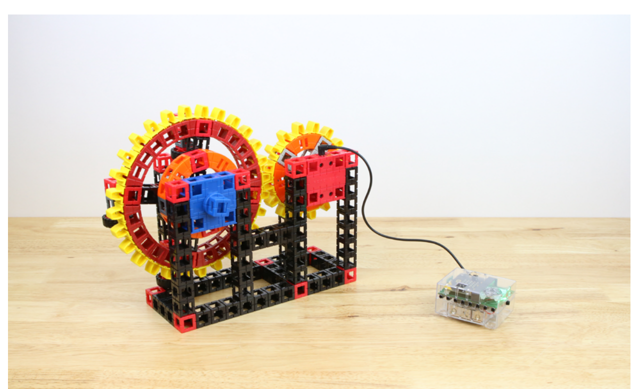
Purpose: Amusement ride

Design Notes: The ferris wheel is powered by a motor module that is connected to a simple gear train. In this example, a small gear is connected to the motor module and used to drive the larger gear. This setup increases the rotating torque of the ferris wheel. The ferris wheel is controlled using the Spark:bit.

Dimensions: 32 cm x 16 cm x 26 cm (L x D x H)

Material Cost: 115 components x $2 = $230





Challenge Evaluation

When teams have completed the Design & Engineering Challenge, it should be presented to the teacher and classmates for evaluation. Teams will be graded on the following criteria:

- **Design and Engineering Process:** Did the team complete each step of the Design and Engineering Process?
- **Design Specification:** Did the team complete a design specification?
- **Team Collaboration:** How well did the team work together? Can each student describe how they contributed?
- **Design Quality/Aesthetics:** Is the design of high quality? Is it structurally strong, attractive, and well-proportioned?
- **Presentation:** How well did the team communicate/explain all aspects of the design to others?

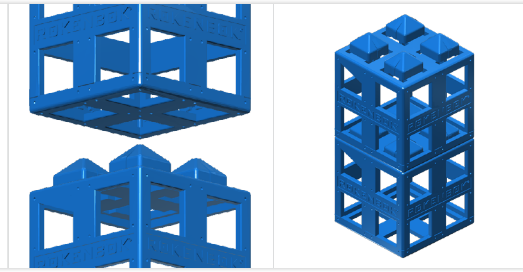
Grading Rubric	Advanced 5 Points	Proficient 4 Points	Partially Proficient 3 Points	Not Proficient 0 Points
Design & Engineering Process	☐ Completed all 5 steps of the process	☐ Completed 4 steps of the process	☐ Completed 3 steps of the process	☐ Completed 2 or fewer steps of the process
Design Specification	☐ Complete/well-detailed and of high quality	☐ Complete/opportunities for improvement	☐ Incomplete/opportunities for improvement	☐ Incomplete
Team Collaboration	☐ Every member of the team contributed	☐ Most members of the team contributed	☐ Few members of the team contributed	☐ Team did not work together
Design Quality/ Aesthetics	☐ Great design/great aesthetics	☐ Good design/good aesthetics	☐ Average design/ average aesthetics	☐ Poor design/poor aesthetics
Presentation	☐ Great presentation/ very well-explained	☐ Good presentation/ well-explained	☐ Poor presentation/ poor explanation	☐ No presentation/ no explanation
Points	....	....	....	....
Total Points				.... /25

Building Basics

The following tips will be helpful when using Kid Spark engineering materials.

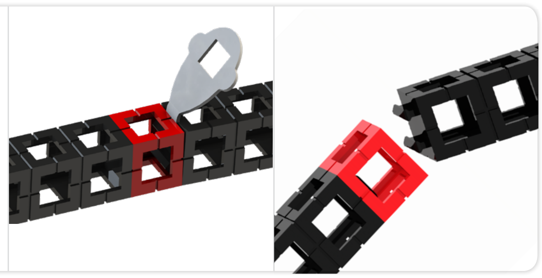
Connecting/Separating ROK Blocks:

ROK Blocks use a friction-fit, pyramid and opening system to connect. Simply press pyramids into openings to connect. To separate blocks, pull apart.



Connecting/Disconnect Smaller Engineering Materials:

Smaller engineering materials use a tab and opening system to connect. Angle one tab into the opening, and then snap into place. To disconnect, insert key into the engineered slot and twist.

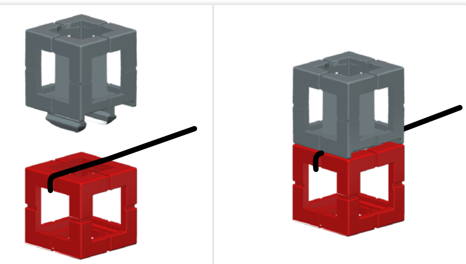


Snapping Across Openings:

Materials can be snapped directly into openings or across openings to provide structural support to a design. This will also allow certain designs to function correctly.

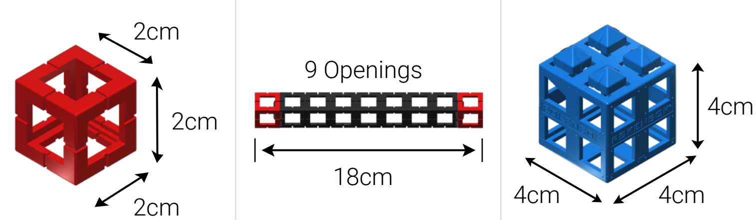
Attaching String:

In some instances, string may be needed in a design. Lay string across the opening and snap any component with tabs or pyramids into that opening. Be sure that the tabs are perpendicular to the string to create a tight fit.



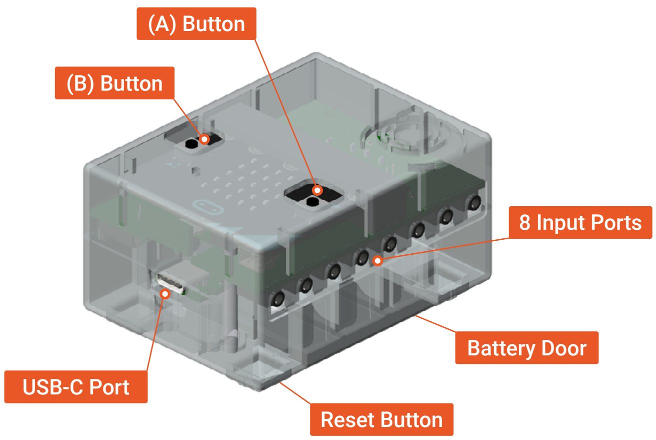
Measuring:

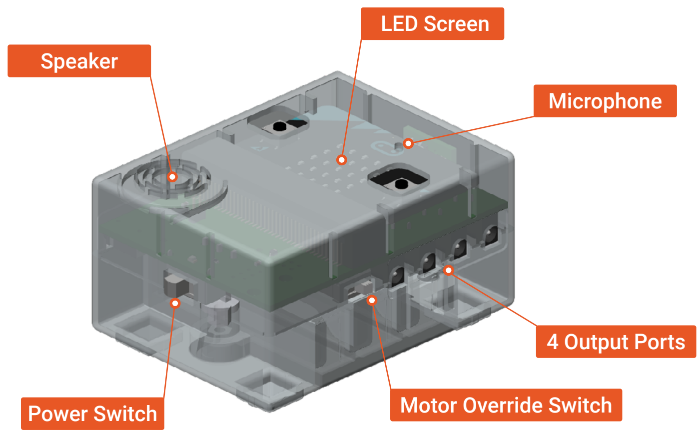
The outside dimensions of a basic connector block are 2 cm on each edge. This means the length, depth, and height are each 2 cm. To determine the size of a project or build in centimeters, simply count the number of openings and multiply by two. Repeat this process for length, depth, and height.



Spark:bit Robotics Controller

The Spark:bit can be programmed to read information from sensors connected to input ports, process that information into relevant commands, and send those commands to modules connected to the output ports. Users can create custom programs using Microsoft's MakeCode programming environment. The Spark:bit is powered by 3 AA batteries and can be connected to a computer using the provided USB-C cable.





Program Reset

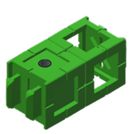
To reset the Spark:bit, press and hold the Reset button. This will reload the last program that was downloaded to it.

Motor Override Mode

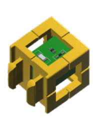
Users can control Motor Modules and Light Modules without having to program the Spark:bit using Motor Override Mode. Once Motor Override Mode has been activated, connect a Motor Module or Light Module to output 1, then press the A & B buttons on the top of the Spark:bit to control the connected device.

Note: *The Spark:bit must be powered on in order for Motor Override Mode to work. A flashing blue light indicates Motor Override Mode is activated. Make sure to deactivate Motor Override Mode when using the Spark:bit in programming situations.*

Input Sensors & Cables

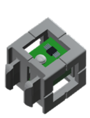

Angle Sensor

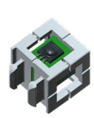

Bump Sensor


Light Sensor


Sensor Cable


High Power IR Transmitter

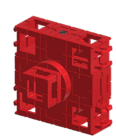

Low Power IR Transmitter


IR Sensing Receiver

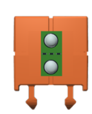

Sensor Cable Extender

Tip: Make sure cables are pressed firmly into connecting ports to ensure a good connection.

Output Modules & Cables


Motor Module


Motor/Output Cable


Light Module


Motor/Output Cable Extender

Rotary Motion

v3.0

Mechanisms & Movement | **Student Engineering Workbook**

Team Members:

1. ______________________ 3. ______________________

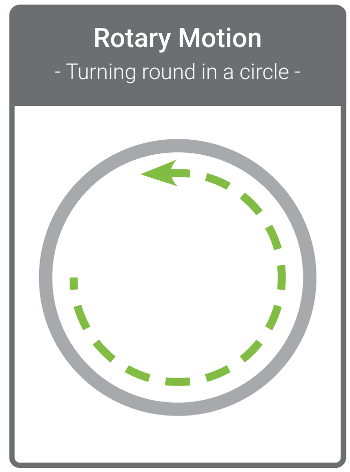
2. ______________________ 4. ______________________

Total Points	
Workbook: ………..	/7 pts
Challenge: ………..	/25 pts

Exploring Rotary Motion

Instructions: Write the correct answer in the spaces provided.

1. _______________ _______________ is motion that turns round in a circle.



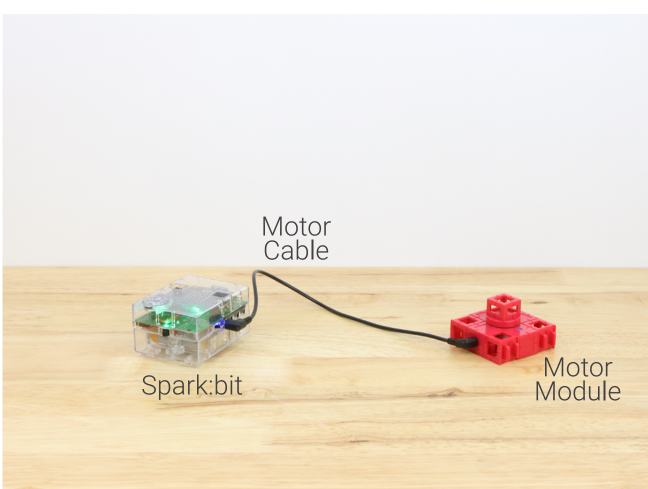
Instructions: Place a check in each box as each step is completed.

2. ☐ Locate an Axle Block and a Snap-In Wheel, and observe how they create rotary motion.

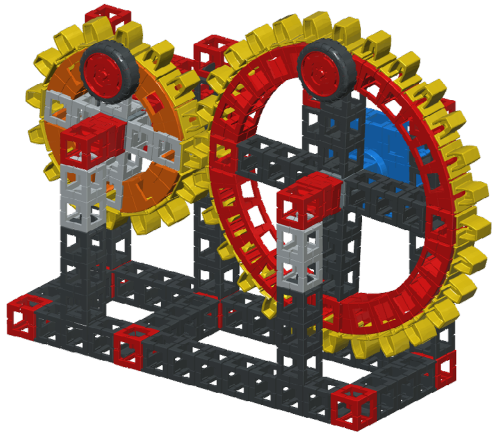
3. ☐ Try and locate a few additional engineering materials in the Kid Spark Lab that produce rotary motion.

4. ☐ Discuss and/or research real-world examples of rotary motion.

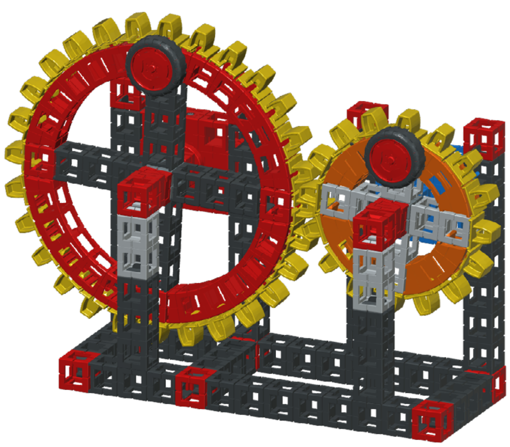
5. ☐ Using a Motor/Output Cable, connect a Motor Module to output 1 on the Spark:bit. Activate Motor Override Mode using the switch located next to output 1 on the Spark:bit. Observe the rotary motion produced by the Motor Module when pressing the A/B buttons on the Spark:bit.



6. ☐ Assemble a simple gear train and observe how it produces rotary motion. Look closely at the rotating gears and observe how they are rotating in opposite directions.



7. ☐ Rearrange the gears so the large gear is connected to the motor module and the small gear is connected to the bearing module. Activate the gear train and observe how much faster the small gear is rotating than the large gear.



Design & Engineering Challenge

Follow each step in the Design & Engineering Process to develop a solution to the challenge.
Place a check in each box as each step is completed. Fill in the blanks when necessary.

1. Identify The Challenge

   ☐ Challenge: ____

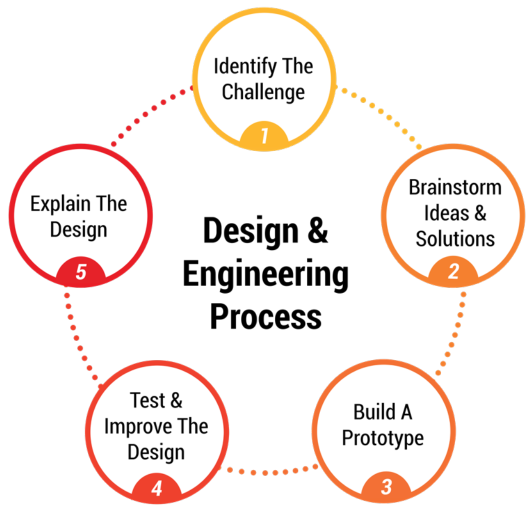
2. Brainstorm Ideas & Solutions

   ☐ Discuss design ideas.

   ☐ Consider building components.

   ☐ Sketch out design ideas on paper.

   ☐ Choose the best design.



3. Build A Prototype

   ☐ Use Kid Spark engineering materials to build a prototype.

4. Test & Improve The Design

   ☐ Look for opportunities to improve the design. (Is it practical, proportional, etc..)

   ☐ Review challenge specifications/criteria and grading rubric.

5. Explain The Design

   ☐ Determine the specifications of the design that was created. *Student Engineering Workbook - Page 3*

   ☐ Discuss the following items with your team and be prepared to share with the rest of the class.

   a. How did the team arrive at the final design solution? Discuss how each step in the Design & Engineering Process was used to develop the design.

   b. Is the design realistic and well-proportioned?

   c. How did each team member contribute towards the overall design? Do you feel like everyone had an equal opportunity to contribute in the creative process?

   d. Is the team prepared to share detailed specifications of the design to others?

Design Specification

Determine the specifications of the completed design/project. Teams can use these specifications as they prepare to present their design to others.

Product Innovation/Invention: ____

Purpose: ____

Engineering Notes:
(How does the design work? Are there any key engineering materials that make the design function well?)

____

____

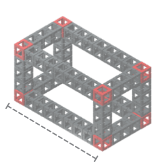
____

____

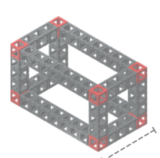
____

____

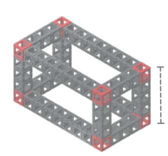
Project Dimensions


Length

________ cm


Depth

________ cm


Height

________ cm

Cost Analysis

Engineering materials used: ________ x 2 = Total Cost $ ________

Challenge Evaluation

When teams have completed the Design & Engineering Challenge, it should be presented to the teacher and classmates for evaluation. Teams will be graded on the following criteria:

- **Design and Engineering Process:** Did the team complete each step of the Design and Engineering Process on page 3?
- **Design Specification:** Did the team complete the design specification on page 4?
- **Team Collaboration:** How well did the team work together? Can each student describe how they contributed?
- **Design Quality/Aesthetics:** Is the design of high quality? Is it structurally strong, attractive, and well-proportioned?
- **Presentation:** How well did the team communicate/explain all aspects of the design to others?

Grading Rubric	Advanced 5 Points	Proficient 4 Points	Partially Proficient 3 Points	Not Proficient 0 Points
Design & Engineering Process	☐ Completed all 5 steps of the process	☐ Completed 4 steps of the process	☐ Completed 3 steps of the process	☐ Completed 2 or fewer steps of the process
Design Specification	☐ Complete/well-detailed and of high quality	☐ Complete/opportunities for improvement	☐ Incomplete/opportunities for improvement	☐ Incomplete
Team Collaboration	☐ Every member of the team contributed	☐ Most members of the team contributed	☐ Few members of the team contributed	☐ Team did not work together
Design Quality/ Aesthetics	☐ Great design/great aesthetics	☐ Good design/good aesthetics	☐ Average design/ average aesthetics	☐ Poor design/poor aesthetics
Presentation	☐ Great presentation/ very well-explained	☐ Good presentation/ well-explained	☐ Poor presentation/ poor explanation	☐ No presentation/ no explanation
Points	....	....	....	....
Total Points				.... /25

Rotary Motion

v3.0

Mechanisms & Movement | **Teacher Lesson Plan**

Overview:

In this lesson, students will learn how to create rotary motion using Kid Spark engineering materials. Students will build a simple gear train and observe how it creates rotary motion. Then, students will work as a team to create a custom design that produces rotary motion.

Click here to explore the entire Kid Spark Curriculum Library.

Activity Time:

120 Minutes

Note: This lesson can easily be taught over the course of two class periods.

Period 1 - Convergent Learning Activity
Period 2 - Divergent Learning Activity

Targeted Grade Level:

2 - 5

Student Grouping:

Teams of up to 4 students

Additional Lesson Materials:

- Curriculum Packet
- Student Engineering Workbook

Kid Spark STEM Lab:

STEM Pathways **or**
Engineering Pathways (w/Spark:bit)

Learning Objectives & NGSS Alignment:

- Define rotary motion.
- Build a gear train and observe how it creates rotary motion.
- Create a custom design that produces rotary motion.

Scientific/Engineering Practice - Asking questions & defining problems
Crosscutting Concept - Cause & effect; mechanism & explanation

Pre-Lesson Preparation:

1. Prepare enough lesson materials for each team. (Curriculum Packets, Student Engineering Workbooks)
2. Become familiar with the concept of rotary motion. *Curriculum Packet - Pages 1 - 2*
3. Prepare an example solution for the Design and Engineering Challenge. *Curriculum Packet - Page 7*

Convergent Learning Activity:

1. Introduce students to the concept of rotary motion. Discuss some real-world examples of rotary motion (wheels on a car, a ceiling fan, etc..). Then, explore how different Kid Spark engineering materials can be used to create rotary motion. *Curriculum Packet - Pages 1 - 2*
2. Instruct teams to assemble a simple gear train. *Curriculum Packet - Pages 3 - 5*
3. Work with teams as they observe the rotary motion produced by the gear train. Point out how the gears are rotating in opposite directions. *Curriculum Packet - Page 6*
4. Discuss how the arrangement of the small and large gears determine if the gear train will increase torque or speed. *Curriculum Packet - Page 6*

   To increase torque (a twisting force that causes rotation) using a gear train, a motor module should be directly connected to a small gear and used to drive a large gear.

   To increase speed using a gear train, a motor module should be directly connected to a large gear and used to drive a small gear.
5. Instruct teams to rearrange the gear train so the large gear is connected to the motor module and the small gear is connected to the bearing module. *Note: This arrangement increases the output speed of the gear train.* *Curriculum Packet - Page 6*

Divergent Learning Activity:

1. Review the Design & Engineering Challenge with teams. *Curriculum Packet - Page 7*
2. Instruct teams to use the Kid Spark Design & Engineering Process to develop a solution to the challenge. *Student Engineering Workbook - Page 3*
3. Instruct teams to fill out the design specification after they have completed their project. *Student Engineering Workbook - Page 4*
4. Review the challenge rubric with teams so they understand how they will be evaluated for the project. *Student Engineering Workbook - Page 5*
5. Consider setting strict time boundaries for the divergent learning activity (see example below). Keep in mind that teams won't always complete a design that works or looks as intended. That's alright! Students can learn a lot by reflecting on their experience and considering what they might have done differently if they had more time or could start the project over.

    a. Review the challenge with teams. (2 minutes)

    b. Teams work through the Design and Engineering Process to create a design. (30 minutes)

    c. Teams complete design specification. (10 minutes)

    d. Teams present designs to class. Each team has 1 minute max to present. (10 minutes)

    e. Lab cleanup. (8 minutes)

Lesson Closure:

1. Project presentations - Instruct each team to share the design they created with the rest of the class.
2. Lab cleanup - After teams have finished their presentations, instruct them to disassemble their designs and pack all engineering materials back into the labs correctly by referring to the Inventory and Organization Guide.
3. Lesson reflection - If time permits, do a quick recap/review of the lesson.

Assessment/Evaluation:

A. Student Engineering Workbook (7 Points)

B. Design & Engineering Challenge (25 Points)