STUDEBAKER NATIONAL MUSEUM

PROGRAM: *DRIVEN BY DESIGN* STEM RACETRACK
AUDIENCE: K-12TH GRADE, FAMILIES

Summary

Driven to Design is educational program that features a derby-style racetrack, track equipment, LEGO components, and supporting hardware. Students and families are challenged to build a LEGO race car, using Studebaker vehicles as their inspiration, and race their creations down the track (solo or against other guests). They are encouraged to refine or change their designs, based on their car's performance. The program utilizes open-ended prompts and suggestions to help guests think through the engineering design process and learn important STEM skills.

Outcome Goal 1: Expand the Museum's capacity for families and elementary-age children, with a focus on play, creativity, and STEM (Science, Technology, Engineering and Math).

Outcome Goal 2: Introduce children and families to STEM concepts, and the *Engineering Design Process*, specifically, by designing, building, and testing LEGO race cars. LEGO is a great platform for this type of program; the variety of available pieces and endless building configurations encourages creativity and iterative design.

By engaging in this activity, participants will:

- **Know** the basic components that make up a car (chassis, wheels, body), and how the *Engineering Design Process* works.
- **Understand** that there are many ways to solve a problem and/or approach an engineering challenge.
- **Demonstrate** their innate creativity and STEM skills, specifically the *Engineering Design Process*, by designing, building, and testing a LEGO race car, and improving or revising their design based on performance.

Activity

- **Welcome.**
  - Welcome family or group to the activity. Define the *Engineering Design Process*, explain the challenge, and introduce the available components. If needed, assist the parent, guardian, or teacher in finding places around the tables for children to build their respective vehicles, starting with a chassis and wheels.
- **Engineering Design Process.**

- The *Engineering Design Process* is a mindset that encourages and emphasizes open-ended problem solving and learning from failure. There are six—sometimes seven—distinct steps in the process.
    - **Define the Goal.** *I need to build a fast car out of LEGO pieces that can travel down a racetrack.*
    - **Imagine and Plan.** *I will think about what kind of car I want to build and start collecting pieces.*
    - **Prototype and Create.** *I will build my car!*
    - **Test/Experiment.** *I will test my car on the track!*
    - **Improve.** *I tested my car. It was fast, but I think I can make it go faster if I change a few things.*
    - **Share.** *My car was awesome! I'm going to tell my friends what worked well!*
- Since this is an informal learning experience, it is sufficient that participants are made aware of the concepts in the *Engineering Design Process* and their application to this activity and other "every day" activities and scenarios.

- **Structured vs. Unstructured (School Group vs. Free Play)**
    - **Structured.** In this scenario, a facilitator will guide the program. After welcoming the group, he/she will determine the size of the group and break the larger group out into smaller teams and assign them build stations. When a group of 3-4 is ready to test, they can flag down a facilitator and bring their cars to the test track. The facilitator will continue to monitor the activity, assist where needed, and provide constructive feedback and suggestions before, during, and after testing (see **Prompts** section below).
    - **Unstructured.** In this scenario, an adult like a teacher, parent, or guardian will facilitate the program for their respective group. Activity signage will explain the challenge, and it will be up to the facilitator(s) to guide their group through the activity. Only an adult can place cars on the test track and launch them down the track. Note that an adult *must be present* for children younger than 12 to participate.
- **Challenges**
    - **Fastest Car.** In this challenge, participants will design a car that travels faster than their competitors and crosses the finish line first. This is the "default" challenge.
    - **Fewest Pieces.** In this challenge, participants will design a fast car using the fewest pieces. The top 2-4 cars with the fewest pieces can race each other to determine the fastest.
    - **Best Design.** In this challenge, participants will design an aesthetically pleasing car. This could be totally subjective, or based on a set of criteria (e.g., build a car inspired by a vehicle in the museum's collection). Other

participants will vote on a winner or winners. The top 2-4 can race each other to determine the fastest.
  - **Tournament.** In this challenge, groups of 2-4 will compete on the track. One winner from each race will compete in a tournament-style bracket, until there is one champion.
- **Building**
  - Participants are welcome to use any available LEGO pieces to build their car, as long pieces are being shared among the group. The only rule is that their car must fit in a single track lane and not touch or otherwise impede another car.
- **Testing & Retesting**
  - When participants are ready to test their car, they will alert an adult like a facilitator or teacher. Depending on the size and nature of the group, participants can have one or more "test runs" before they compete. Similarly, a group of 2-4 cars can race each other down the track before they "officially" compete—this is a helpful way for kids to establish a "baseline" and see what they might improve upon. The adult will place the car behind the starting gate on one of the four track lanes. When 2-4 cars have been placed (depending on the size of the group), the adult will use the remote to release the gates—the cars will rush down the track toward the finish line and SOF (Sequence of Finish) timer. If for some reason a car gets stuck or doesn't leave the gate, the race can be restarted; if a car breaks apart, an adult can help a participant by gathering the pieces and troubleshooting what they can do fix and/or revise their design. Participants can improve their designs and retest/race as often as they have time for, unless they are racing in a tournament-style competition.
- **Wrap-Up**
  - When a group has finished, instruct them to disassemble their cars and return the pieces to their proper containers. Thank the group for racing today and encourage them to explore the exhibits (if they haven't already) to look for their favorite Studebaker!

Prompts

- *What do you think are the most important parts on your car?*
- *We're using gravity to power our cars instead of an engine! What do you think will help your car move faster down the track?*
- *What kind of LEGO pieces are you using for your body? Why?*
- *Tell me about your design!*
- *What about your design worked well? What didn't work so well? How could you improve your design next time?*

- *What if you…*
    - *Moved the wheels to a different spot on the chassis?*
    - *Tried different wheels?*
    - *Tried a different chassis?*
    - *Added more/less weight?*
    - *Made your car longer/shorter?*

Adapting for Audience

- **Early Elementary (K - 2nd)**
    - Young children will likely need more adult guidance in this activity. Facilitators, teachers, or parents can talk about the parts of a car and suggest pieces that kids might want to try when building. Children do not need to race their cars if they are content building. Many will need assistance in connecting pieces together.
- **Mid Elementary (3rd – 5th)**
    - This is the "target" audience for this activity. Most children will be familiar with LEGO will be self-sufficient when building but depending on the size of the group they will likely require special handling when it comes to testing. If a school group, one teacher or chaperone can act as a facilitator for each small group of students.
- **Late Elementary/Middle School (6th - 8th)**
    - Similar to younger elementary-age age children, this group will be mostly self-sufficient but will need to be managed when testing. Additional variations to the "primary" challenge can be introduced, as well (e.g. build a car with the fewest LEGO pieces). Facilitators can go more in-depth about the *Engineering Design Process* and why experimentation and iteration are so important.
- **High School (9th – 12th)**
    - High school-age participants will be mostly self-sufficient. It might help keep this age group on track with a tournament, or add an extra element to the challenge (e.g. build a car inspired by a Studebaker in the museum). If their visit is connected to a curriculum standard or project there are other scientific concepts or scenarios that could be introduced, as well. <u>An additional challenge for this group could also include limiting or assigning the number of weighted bricks per student.</u>
- **Families**
    - Families are composed of children of varying ages; with these participants, encourage parent-child interaction and playfulness. Facilitators can take a more "hands-off" approach if participants consist of one or more families.
- **Other Groups**

Assessment

- **Observation.** The activity will be regularly observed by museum staff in an effort to make sure outcomes align with goals and to improve the overall experience for participants.
- **Student Survey.** After participating, teachers will distribute simple assessment to students asking them what they liked and didn't like about the activity. These will be collected and given to Museum staff.
- **Teacher/Chaperone Survey.** Teachers will complete a brief assessment on how/if the activity enhanced their overall visit and what/if their students learned anything. These will be returned to Museum staff.
- **Participant Survey.** A more open-ended survey will be offered with the activity for participants to fill out if they so desire (e.g. parents with young children). These will be collected on occasion by Museum staff.

Set Up Procedure

1. Set up work tables in program area, if not already done. Set up pull-up banner.
2. Carefully load the wooden box containing the track segments, 2 large storage bins, and pull-up banner onto a flatbed cart and transport to program location.
3. With two people lifting either end, move the box onto the ground and set up the top track segment with folding legs. Be careful not to damage the gate release mechanism when moving this segment.
4. Connect the remaining track segments, and secure together using the provided screws and washers. Place the SOF time at the end of the bottom track segment and connect the stopping tracks using small screws.
5. Plug in the gray ethernet cord for the SOF time into the black box mounted near the gate mechanism. Then, plug the power cord into the extension cord and plug that into the wall. Use the metal clips attached to the track frame to tuck the ethernet cord against the track so children don't trip on it.
6. Depending on the position of the track, place short stanchions along both sides of the track (especially the portion sitting on the ground) so participants don't jump over the track and risk injuring themselves.
7. Test the SOF timer and gate mechanism with a LEGO car. Note that the gate can be manually released, or the wireless remote can be used. If the gate is not working properly, check to make sure the magnet on the release arm is aligned with the solenoid in the black box.
8. Depending on the number of participants, place one LEGO kit bin and two plastic trays per station or tale. Dump out some LEGO pieces in the trays for easier access

to pieces. Next, place one Wheels/Chassis kit at each station. Remove internal trays for easier access to pieces.

Equipment List

Item
32-ft 4-lane race track (folding top track segment, track segments, stopping tracks)
Storage box for track segments
Mixed bungie cords
SOF Timer & power cord
1 Extension cord
1 Mini SKIL cordless screwdriver
Metal clips for SOF power cord organization
4 LEGO kits (miscellaneous LEGO pieces in numbered bins)
1 Container with pre-built LEGO chassis & wheels
4 Chassis/Wheel kits (miscellaneous weighted bricks, wheels, LEGO chassis, etc. in numbered bins)
1 Hardware kit (storage for screws, washers, extra clips, tools, etc.)
8 Plastic trays for LEGO pieces
2 Large bins to store all program components, except for track and pull-up banner
Hand truck
2-4 6-ft tables
Pull-up banner
Miscellaneous museum literature, additional program signage, etc.

Indiana State Curriculum Standards – Science

The K-12 Science Indiana Academic Standards outline the knowledge, science, and engineering practices that all students should learn by the end of high school. They are based on *A Framework for K-12 Science Education* (NRC, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013). For more information, please visit in.gov/doe.

Kindergarten

K-PS2-1 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can: Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

Disciplinary Core Ideas:
PS2.A: Forces and Motion
PS2.B: Types of Interactions
PS3.C: Relationship Between Energy and Forces

Crosscutting Concepts:
CC2. Cause and Effect

Science and Engineering Practices:
SEP.3: Planning and Carrying Out Investigations

K-PS2-2 Motion and Stability: Forces and Interactions
Students who demonstrate understanding can: Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

Disciplinary Core Ideas:
PS2.A: Forces and Motion
ETS1.A: Defining Engineering Problems

Crosscutting Concepts:
CC2. Cause and Effect

Science and Engineering Practices:
SEP.4: Analyzing and Interpreting Data

K-2-ETS1-1 Engineering Design
Students who demonstrate understanding can: Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Disciplinary Core Ideas
ETS1.A: Defining and Delimiting Engineering Problems

Science and Engineering Practices:
SEP.1: Asking Questions and Defining Problems

K-2-ETS1-2 Engineering Design
Students who demonstrate understanding can: Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a simple problem.

Disciplinary Core Ideas
ETS1.B: Developing Possible Solutions

Crosscutting Concepts:
CC.6: Structure and Function

Science and Engineering Practices:
SEP.2: Developing and Using Models

K-2-ETS1-3 Engineering Design

Students who demonstrate understanding can: Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Disciplinary Core Ideas
ETS1.C: Optimizing the Design Solution

Science and Engineering Practices:
SEP.4: Analyzing and Interpreting Data

Grade 1

The **Engineering Design standards for Grade 1 as they relate to this program are the same as those used for Kindergarten and build on prior experiences and progresses.

Grade 2

The **Engineering Design standards for Grade 2 as they relate to this program are the same as those used for K-Grade 1 and build on prior experiences and progresses.

Grade 3

3-PS2-1 Motion and Stability: Forces and Interactions
Students who demonstrate understanding can: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Disciplinary Core Ideas:
PS2.A: Forces and Motion
PS2.B: Types of Interactions

Crosscutting Concepts:
CC.2: Cause and Effect

Science and Engineering Practices:
SEP.3: Planning and Carrying Out Investigations

3-PS2-1 Motion and Stability: Forces and Interactions
Students who demonstrate understanding can: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Disciplinary Core Ideas:
PS2.A: Forces and Motion

Crosscutting Concepts:
CC.1: Patterns

Science and Engineering Practices:
SEP.3: Planning and Carrying Out Investigations

3-5-ETS1-1 Engineering Design

Students who demonstrate understanding can: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Disciplinary Core Ideas:
ETS1.A: Defining and Delimiting Engineering Problems

Crosscutting Concepts:
Influence of Science, Engineering, and Technology on Society and the Natural World

Science and Engineering Practices:
SEP.1: Asking Questions and Defining Problems

3-5-ETS1-2 Engineering Design

Students who demonstrate understanding can: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Disciplinary Core Ideas:
ETS1.B: Developing Possible Solutions

Crosscutting Concepts:
Influence of Science, Engineering, and Technology on Society and the Natural World

Science and Engineering Practices:
SEP.6: Constructing Explanations and Designing Solutions

3-5-ETS1-3 Engineering Design

Students who demonstrate understanding can: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Disciplinary Core Ideas:
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution

Science and Engineering Practices:
SEP.3: Planning and Carrying Out Investigations

Grade 4

The **Motion and Stability: Forces and Interactions standards for Grade 4 (3-5) as they relate to this program are the same as those used for K-Grade 2 and build on prior

experiences and progresses, with respect to the following Science and Engineering Practices:

- Investigations that control variables and provide evidence to support explanations and design solutions (SEP.3)

The **Engineering Design standards for Grade 4 (3-5) as they relate to this program are the same as those used for K-Grade 2 and build on prior experiences and progresses, with respect to the following Science and Engineering Practices:

- Specifying qualitative relationships (SEP.1)
- Using evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems (SEP.6)
- Investigations that control variables and provide evidence to support explanations and design solutions (SEP.3)

Grade 5

The **Engineering Design standards for Grade 5 (3-5) as they relate to this program are the same as those used for K-Grade 2 and build on prior experiences and progresses, with respect to the following Science and Engineering Practices:

- Specifying qualitative relationships (SEP.1)
- Using evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems (SEP.6)
- Investigations that control variables and provide evidence to support explanations and design solutions (SEP.3)

Grade 6

MS-ETS1-1 Engineering Design

Students who demonstrate understanding can: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Disciplinary Core Ideas:
ETS1.A: Defining and Delimiting Engineering

Crosscutting Concepts:
Influence of Science, Engineering,

Problems

Technology on Society and the Natural World

Science and Engineering Practices:
**SEP.1: Asking Questions and Defining Problems

Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models.

<u>MS-ETS1-2 Engineering Design</u>
Students who demonstrate understanding can: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Disciplinary Core Ideas:
ETS1.B: Developing Possible Solutions

Science and Engineering Practices:
**SEP.7: Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

<u>MS-ETS1-3 Engineering Design</u>
Students who demonstrate understanding can: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Disciplinary Core Ideas:
ETS1B: Developing Possible Solutions
ETS1C: Optimizing the Design Solution

Science and Engineering Practices:
**SEP.4: Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

MS-ETS1-4 Engineering Design
Students who demonstrate understanding can: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Disciplinary Core Ideas:

ETS1B: Developing Possible Solutions
ETS1C: Optimizing the Design Solution

**SEP.2: Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

Grade 7

MS-PS2-1 Motion and Stability: Forces and Interactions
Students who demonstrate understanding can: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.

Disciplinary Core Ideas:
PS2.A: Forces and Motion

Crosscutting Concepts:
CC.4: Systems and System Models
Influence of Science, Engineering, and Technology on Society and the Natural World

Science and Engineering Practices:
**SEP.6: Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

MS-PS2-2 Motion and Stability: Forces and Interactions
Students who demonstrate understanding can: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Disciplinary Core Ideas:
SEP.3: Planning and Carrying Out Investigations
Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence

Crosscutting Concepts:
CC.7: Stability and Change

Science and Engineering Practices:
SEP.3: Planning and Carrying Out Investigations

MS-PS3-1 Energy

Students who demonstrate understanding can: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

Disciplinary Core Ideas:
PS3.A: Definitions of Energy

Crosscutting Concepts:
CC.3: Scale, Proportion, and Quantity

Science and Engineering Practices:
SEP.4: Analyzing and Interpreting Data
** Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

MS-PS3-5 Energy
Students who demonstrate understanding can: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Disciplinary Core Ideas:
PS3.B: Conservation of Energy and Energy Transfer

Crosscutting Concepts:
CC.5: Energy and Matter

Science and Engineering Practices:
**SEP.7: Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds.

Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence

The **Engineering Design standards for Grades 6-8 as they relate to this program are the same as those used for K-Grade 5 and build on prior experiences and progresses, with respect to the following Science and Engineering Practices:

- Specifying relationships between variables
- Clarifying arguments and models

- Constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world

Grade 8

The **Engineering Design standards for Grades 6- 8 as they relate to this program are the same as those used for K-5 and build on prior experiences and progresses.

High School Physics

HS-PS2-1 Forces and Interactions

Students who demonstrate understanding can: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Disciplinary Core Ideas:
PS2.A: Forces and Motion

Crosscutting Concepts:
CC.2: Cause and Effect

Science and Engineering Practices:
SEP.4: Analyzing and Interpreting Data
Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

HS-PS2-2 Forces and Interactions

Students who demonstrate understanding can: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

Disciplinary Core Ideas:
PS2.A: Forces and Motion

Crosscutting Concepts:
CC.4: Systems and System Models

Science and Engineering Practices:
SEP.5: Using Mathematics and Computational Thinking

HS-PS2-3 Forces and Interactions

Students who demonstrate understanding can: Apply scientific and engineering ideas to design, evaluate, and refine a device for example, one that minimizes the force on a macroscopic object during a collision.

Disciplinary Core Ideas:

Crosscutting Concepts:

PSA.2: Forces and Motion
ETS1.A: Defining and Delimiting an Engineering Problem
ETS1.C: Optimizing the Design Solution

CC.2: Cause and Effect

Science and Engineering Practices:
SEP.6: Constructing Explanations and Designing Solutions

Driven to Design: LEGO Racetrack