## 5E Integrated STEAM Lesson Plan – Draft

**Lesson Title:** Paper Ball Run Challenge

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**Topic:** Kinematics, Energy, Simple Machines

**Targeted Grade Level:** Grades 6-8

**Time Needed:**  2 Weeks

**Subject Integration:**  Science, Technology, Engineering, Art, Math

**Justification:**  In this lesson, multiple subjects will be integrated; students will use art, problem-solving, and the engineering design process to create several iterations of a ball run based on specific criteria.

**Standards:**

**MA : Cr1.1.7** - Produce a variety of ideas and solutions for media artworks through application of chosen inventive processes such as concept modeling and prototyping.

**MA : Pr5.1.7a** - Exhibit an increasing set of artistic, design, technical, and soft skills through performing various roles in producing media artworks, such as creative problem-solving and organizing.

**MA : Pr5.1.7b** - Exhibit an increasing set of creative and adaptive innovation abilities, such as exploratory processes, in developing solutions within and through media arts productions.

## NGSS Performance Expectations

**MS-ETS1-1.** 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.

**MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**MS-ETS1-3.** 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.

**MS-ETS1-4.** 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.

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
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| **Asking Questions and Defining Problems**<br>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.<br>• Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)<br>**Developing and Using Models**<br>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.<br>• Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)<br>**Analyzing and Interpreting Data**<br>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.<br>• Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)<br>**Engaging in Argument from Evidence**<br>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.<br>• Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2) | **ETS1.A: Defining and Delimiting Engineering Problems**<br>• The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)<br>**ETS1.B: Developing Possible Solutions**<br>• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)<br>• There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)<br>• Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)<br>• Models of all kinds are important for testing solutions. (MS-ETS1-4)<br>**ETS1.C: Optimizing the Design Solution**<br>• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)<br>• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4) | **Influence of Science, Engineering, and Technology on Society and the Natural World**<br>• All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)<br>• The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1) |

**Measurable Student Learning Objectives:**

Students will be able to make designs for a ball run based on specific criteria; choose which design will perform better based on the criteria; and build and iteratively test their designs; explain how conservation of energy applies to the ball run in terms of gravitational potential energy, kinetic energy, and friction.

**Nature of STEM:**  These lessons address NOSTEM through a variety of activities incorporating STEAM; some prior knowledge from activities, lessons, and materials is necessary.

**Engaging Context/Phenomena:**  The lesson begins with a video called "World's greatest paper roller coaster"; art standards are addressed through sketchnoting (p. 32) - previous knowledge of sketchnoting required.

**Data Integration:**  Score from Run Challenge - students will count materials vs. time - converting to seconds.  Class challenge and Fluor Challenge determine winner.

**Differentiation of Instruction:**  For group work - students will be placed into groups of three based on MAP data for reading (Lexile).

**Real-life Connection:**  Career Connections - Civil Engineering/STEM careers

## Lesson Procedure:

| 5E Model | Unit Overview |
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| **Engage**<br><br>Introduce the lesson with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about what students already know and want to know. | **Procedure:**  Students will view the video [World's Greatest Paper Roller Coaster](#) to view construction ideas, etc., and discuss conservation of energy/gravitational potential energy and kinetic energy.  Discuss experiences with roller coasters. (Holiday World, etc); Find pictures of favorite roller coasters to share with groups and discuss similarities and differences.<br><br>**Modifications:**  Groups of 3 based on MAP scores.<br><br>**Standards Addressed:**  MA : Cr1.1.7, MA : Pr5.1.7a, MA : Pr5.1.7b<br><br>**Formative/Summative Assessments:**  [Design choices from sketchnoting](#).<br><br>**Resources:**  [Verbal to Visual Notebook](#) |
| **Explore**<br><br>Plan for students to engage in hands-on activities that are designed to facilitate conceptual change. | **Procedure:**  Physics Simulation Roller Coaster Model; practice with templates; experimenting with ping-pong ball.<br><br>**Modifications:**   Groups of 3 to determine ramp models to slow ball.<br><br>**Standards Addressed:**  NGSS - MS-ETS1-4<br><br>**Formative/Summative Assessments:**  Concept checker from Physics simulation<br><br>**Resources:**  [Physics Simulation: Roller Coaster Model](#) |
| **Explain**<br><br>Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts. | **Procedure:**  Designing several different runs using sketchnoting - each group should design 2 each before any building takes place.  Reminder of the amount of materials they are allowed.  Consider how the final score will be determined.<br><br>**Modifications:**  [Paper template](#) copies if necessary.<br><br>**Standards Addressed:**  NGSS; ELA - Literacy<br><br>**Formative/Summative Assessments:**<br><br>[how-roller-coasters-work-50887-article_quiz_and_answers.pdf](#)<br><br>**Resources:**  Newsela; sketchnoting; roller coaster paper template |

| **Elaborate**<br><br>Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills. | **Procedure:** 2022 Fluor Challenge - building the slowest paper ball run.<br><br>**Modifications:** Groups of 3 - criteria/material constraints; Test/Iterate<br><br>**Standards Addressed:** MS-ETS1-4.<br><br>**Formative/Summative Assessments:** Student worksheets - calculating scores<br><br>**Resources:**<br><br>Fluor Challenge 2022 |
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| **Evaluate**<br><br>Assess students' knowledge, skills and abilities. | **Procedure:** Classwide competition; discussion from results; presentations; teamwork<br><br>**Modifications:**<br><br>**Standards Addressed:** NGSS<br><br>**Formative/Summative Assessments:** Oral presentations - Poster from sketchnoting; team evaluation.<br><br>**Resources:** Final Rubric |

**Teacher Background:**

[Verbal to Visual NB](#)