Randolph Township Schools
Randolph Middle School
Junior Engineering Curriculum

"The science of today is the technology of tomorrow"
-Edward Teller

STEM Department
Melissa Strype, Supervisor

Curriculum Committee
Nick Lavender
Derek Skoldberg

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July 2020

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August 18, 2020

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Mission Statement

We commit to inspiring and empowering all students in Randolph schools to reach their full potential as unique, responsible and educated members of a global society.

Affirmative Action Statement
Equality and Equity in Curriculum

The Randolph Township School district ensures that the district's curriculum and instruction are aligned to the state's standards. The curriculum provides equity in instruction, educational programs and provides all students the opportunity to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

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EDUCATIONAL GOALS
VALUES IN EDUCATION

The statements represent the beliefs and values regarding our educational system. Education is the key to self-actualization, which is realized through achievement and self-respect. We believe our entire system must not only represent these values, but also demonstrate them in all that we do as a school system.

We believe:

- The needs of the child come first
- Mutual respect and trust are the cornerstones of a learning community
- The learning community consists of students, educators, parents, administrators, educational support personnel, the community and Board of Education members
- A successful learning community communicates honestly and openly in a non-threatening environment
- Members of our learning community have different needs at different times. There is openness to the challenge of meeting those needs in professional and supportive ways
- Assessment of professionals (i.e., educators, administrators and educational support personnel) is a dynamic process that requires review and revision based on evolving research, practices and experiences
- Development of desired capabilities comes in stages and is achieved through hard work, reflection and ongoing growth

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Introduction

This is a marking period cycle course offered to eighth grade students interested in technology and engineering. Junior Engineering focuses on civil, mechanical, and structural engineering design concepts. Through an interdisciplinary approach, students will develop and enhance their engineering knowledge and apply problem solving, creative, and technological skills to create real-world solutions. By the end of this course, students will gain a fundamental understanding of the engineering design process, bridge design, projectile motion, and transportation technology. In addition, they will experience the real-world research and communications necessary to be successful in an increasingly technological world. This course will be guided by the current New Jersey Learning Standards in Computer Science and Design Thinking, Career Readiness, Life Literacies, and Key Skills, Science, Mathematics, and English.

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Curriculum Pacing Chart

SUGGESTED TIME ALLOTMENT	UNIT NUMBER	CONTENT - UNIT OF STUDY
4 weeks	**I**	**Bridging the Gap**
2 weeks	**II**	**Projectiles in Motion**
3 weeks	**III**	**Transportation Technology: Dragsters**

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Unit I: Bridging the Gap

<table>
<tr><td colspan="3">TRANSFER: Students will be able to independently engage in the engineering design process to plan, design, collaborate, and develop solutions to real-world problems.</td></tr>
<tr><td rowspan="6">STANDARDS / GOALS:

NJ 2020 SLS: Computer Science and Design Thinking
8.2.8.ED.2: Identify the steps in the design process that could be used to solve a problem.

8.2.8.ED.3: Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).

8.2.8.ED.4: Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.

8.2.8.NT.1: Examine a malfunctioning tool, product, or system and propose solutions to the problem.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>The ability to understand and have a procedural method that will help one solve a problem is a valuable life skill.</td><td>• What is the best way to solve a problem?</td></tr>
<tr><td>In an engineering career, product failure can help improve future performance and inspire positive results.</td><td>• What is the importance of understanding past engineering failures?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td><u>SKILLS</u>
Students will be able to:</td></tr>
<tr><td>The engineering design process is a series of steps that engineers follow to come up with the best solutions to a problem.

A bridge is a structure built to span physical obstacles such as a body of water, valley, or road.</td><td>Identify the different steps of the engineering design process and explain why they are important.

Research past, current, and future bridge architecture.</td></tr>
</table>

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Unit I: Bridging the Gap

NJ 2020 SLS: Career Readiness, Life Literacies, and Key Skills 9.1.8.PB.1: Predict future expenses or opportunities that should be included in the budget planning process. 9.4.8.IML.3: Create a digital visualization that effectively communicates a data set using formatting techniques such as form, position, size, color, movement, and spatial grouping. 9.4.8.TL.3: Select appropriate tools to organize and present information digitally. **NJ 2020 SLS: Science** 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.	The four main types of bridges are arch, beam, truss, and suspension.	Evaluate the strengths and weaknesses of each type of bridge design. Establish small teams to brainstorm and plan bridge project proposals within given criteria and constraints. Sketch an orthographic drawing of a truss bridge design. Develop a budget for purchasing bridge building materials. Redesign a model of a historical bridge collapse. Construct a truss bridge that displays an efficient strength to weight ratio. Test the efficiency of a truss bridge using a bridge testing device.

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Unit I: Bridging the Gap

NJ 2016 SLS: Literacy in History, Social Studies, & Technical Subjects RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts. RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **NJ 2020 SLS: Science – Crosscutting Concepts 6-8** • Cause and effect • Structure and function • Systems and system models **NJ 2020 SLS: Science – Science and Engineering Practices 6-8** • Asking questions and defining problems • Developing and using models • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematics and computational thinking	Built up stresses can add strain to a bridge and continuously wear down its construction. **VOCABULARY:** torsion, tension, compression, procedures, analysis, resources, researching, brainstorming, developing, building, testing, reflection, criteria, constraints **KEY TERMS:** orthographic drawing, beam bridge, arch bridge, suspension bridge, truss bridge, shear, oscillation, cement, tensile strength, blueprint	Identify various stresses such as compression, tension, torsion, bending, and shear. Present data reflecting a historical bridge collapse. Reframe engineering failures into positive results. Research historical bridge collapses and identify multiple stresses on the bridge.

• Constructing explanations and designing solutions **NJ 2020 SLS: Science – Disciplinary Core Ideas 6-8** ETS1.B: Developing Possible Solutions **NJ 2016 SLS: Math** 6.RP.A.1: Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. **NJ 2016 SLS: Mathematical Practices** MP4: Model with mathematics MP5: Use appropriate tools strategically		

ASSESSMENT EVIDENCE: Students will show their learning by:

- Preparing a bridge construction proposal
- Preparing a spreadsheet for budgeting bridge construction materials
- Constructing a model of a historical bridge collapse
- Constructing a truss bridge
- Presenting data on a historical bridge collapse
- Testing truss bridge designs

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Unit I: Bridging the Gap

KEY LEARNING EVENTS AND INSTRUCTION:

- Small group collaboration (planning, analyzing criteria and constraints, and constructing)
- Technical drafting of bridge designs
- Student modeling of constructed designs
- Daily reflections in engineering journal

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Unit I: Bridging the Gap

SUGGESTED TIME ALLOTMENT	**4 weeks**
SUPPLEMENTAL UNIT RESOURCES	Required Supplies/Activities: Computers Various woodworking and crafting tools Measuring and drafting tools Craft Sticks Balsa Wood Suggested Readings: https://theworks.org/wp-content/uploads/2019/08/TheWorksMuseum_Engineering-Design-Process_Poster.pdf https://www.britannica.com/technology/bridge-engineering Suggested Supplies/Activities: "Historical Bridge Collapse Research" "Truss Bridge Proposal" "Truss Bridge Budget" "Truss Bridge Design"

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Unit II: Projectiles in Motion

<table>
<tr><td colspan="3">TRANSFER: Students will be able to independently engage in the engineering design process to plan, design, collaborate, and develop solutions to real-world problems.</td></tr>
<tr><td rowspan="5">STANDARDS / GOALS:
NJ 2020 SLS: Computer Science and Design Thinking
8.2.8.ED.2: Identify the steps in the design process that could be used to solve a problem.

8.2.8.ED.3: Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).

8.2.8.ED.4: Analyze how trade-offs can impact the design of a product.

NJ 2020 SLS: Science
MS-ETS1-1: Define the criteria 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.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>Project restraints and specifications can limit the ability to successfully solve a problem, however it can encourage innovation and/or redesign.</td><td>• Why is it important for engineers to not feel obligated to follow the engineering design process in a specific order?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td><u>SKILLS</u>
Students will be able to:</td></tr>
<tr><td>The engineering design process does not have to be followed in any specific order.

Projectile motion is a form of motion in which an object or particle is thrown near the Earth’s surface, and it moves along a curved path under the action of gravity only.</td><td>Analyze the various steps to the engineering design process and create a pathway suitable for meeting specific project design goals.

Establish small teams to brainstorm and plan a projectile machine design constraints and proposals.

Prepare and develop a budget for purchasing building materials.</td></tr>
</table>

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Unit II: Projectiles in Motion

MS-ETS1-4: Develop a model to generate data for iterative and modification of a proposed object, tool, or process such that an optimal design can be achieved. **NJ 2020 SLS: Career Readiness, Life Literacies, and Key Skills** 9.1.8.PB.1: Predict future expenses or opportunities that should be included in the budget planning process. 9.4.8.TL.1: Construct a spreadsheet in order to analyze multiple data sets, identify relationships, and facilitate data-based decision making. **NJ 2016 SLS: Literacy in History, Social Studies, & Technical Subjects** RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	Catapults are an offshoot or a crossbow and are designed with a pivoting arm. Elastic potential energy is stored in the catapult lever when the lever is bent further from its equilibrium position.	Construct a projectile machine that is built for accuracy and distance. Identify the major similarities and differences between the different forms of catapults: Mangonel, Ballista, and Trebuchet. Explain the key components that make a strong catapult design. Test the efficiency of specific catapult designs. Produce a projectile machine design that meets specific project requirements and exhibits an efficient result. Examine the ideal launch angle for projectiles to travel the farthest distance.

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Unit II: Projectiles in Motion

NJ 2020 SLS: Science – Crosscutting Concepts 6-8 • Cause and effect • Structure and function • Systems and system models **NJ 2020 SLS: Science – Science and Engineering Practices 6-8** • Asking questions and defining problems • Developing and using models • Planning and carrying out investigations • Analyzing and interpreting data • Constructing explanations and designing solutions **NJ 2020 SLS: Science – Disciplinary Core Ideas 6-8** ETS1.A: Defining and Delimiting Engineering Problems ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	**VOCABULARY:** projectile motion, potential energy, fulcrum, equilibrium, feedback, counterweight, researching, brainstorming, developing, building, testing, reflection, constraints **KEY TERMS:** crossbow, catapult, dowel, Mangonel, Ballista, and Trebuchet, project proposal	

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Unit II: Projectiles in Motion

ASSESSMENT EVIDENCE: Students will show their learning by:

- Creating a catapult proposal and budget plan
- Constructing a catapult that is built for accuracy and distance
- Testing catapult designs with a large target

KEY LEARNING EVENTS AND INSTRUCTION:

- Small group collaboration (planning, analyzing criteria and constraints, and constructing)
- Technical drafting of projectile machine
- Preparing a spreadsheet for projectile machine materials
- Student modeling of constructed designs
- Daily reflections in engineering journal

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Unit II: Projectiles in Motion

SUGGESTED TIME ALLOTMENT	**2 weeks**
SUPPLEMENTAL UNIT RESOURCES	Required Supplies/Activities: Computers Various woodworking and crafting tools Craft Sticks Balsa Wood Rubber Bands Dowels Plastic Cups Suggested Readings: https://theworks.org/wp-content/uploads/2019/08/TheWorksMuseum_Engineering-Design-Process_Poster.pdf https://www.physicsclassroom.com/class/vectors/Lesson-2/What-is-a-Projectile Suggested Supplies/Activities: "Catapult Proposal/Budget" "Catapult Test Results"

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Unit III: Transportation Technology: Dragsters

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<tr><td colspan="3">TRANSFER: Students will be able to independently engage in the engineering design process to plan, design, collaborate, and develop solutions to real-world problems.</td></tr>
<tr><td rowspan="5">STANDARDS / GOALS:

NJ 2020 SLS: Computer Science and Design Thinking
8.2.8.ED.2: Identify the steps in the design process that could be used to solve a problem.

8.2.8.ED.3: Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).

8.2.8.ED.4: Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team.

8.2.8.NT.1: Examine a malfunctioning tool, product, or system and propose solutions to the problem.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>The redesigning of a product helps to ensure the products appearance, function, and content.</td><td>• How can engineers modify designs to produce maximum efficiency?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td>SKILLS
Students will be able to:</td></tr>
<tr><td>Aerodynamics is the study of airflow and the forces involved when an object moves through the air or when air moves past an object.

To ensure maximum performance, vehicles are designed to increase power and downforce, while limiting the forces that decrease its potential.</td><td>Research vehicle designs that display excellent aerodynamic abilities.

Establish small teams to brainstorm and plan dragster proposal designs within given criteria and constraints.</td></tr>
</table>

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Unit III: Transportation Technology: Dragsters

NJ 2020 SLS: Career Readiness, Life Literacies, and Key Skills 9.1.8.PB.1: Predict future expenses or opportunities that should be included in the budget planning process. 9.4.8.IML.3: Create a digital visualization that effectively communicates a data set using formatting techniques such as form, position, size, color, movement, and spatial grouping. 9.4.8.TL.3: Select appropriate tools to organize and present information digitally. **NJ 2020 SLS: Science** 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 and modification of a proposed object, tool, or process such that an optimal design can be achieved.	Four forces that affect vehicle airflow are lift, thrust, gravity and drag. The safety procedures on how to properly operate a band saw, drill press, and other wood working equipment.	Outline key components of performance vehicles. Produce a prototype for testing and redesign. Construct a functioning vehicle that is powered by a CO_2 cartridge or compressed air. Explain the importance of limiting specific factors in vehicle design. Design a dragster that limits lift and drag. Prepare and develop a strategic specification that details the important factors of vehicle design. Test the efficiency of specific vehicle designs and include modifications for any necessary redesign. Identify key parts of a band saw and drill press. Assess and handle duty shop equipment safely.

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Unit III: Transportation Technology: Dragsters

NJ 2016 SLS: Literacy in History, Social Studies, & Technical Subjects RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts. RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually) e.g., in a flowchart, diagram, model, graph, or table). **NJ 2020 SLS: Science – Crosscutting Concepts 6-8** • Cause and effect • Structure and function • Systems and system models **NJ 2020 SLS: Science – Science and Engineering Practices 6-8** • Asking questions and defining problems • Developing and using models • Planning and carrying out investigations • Analyzing and interpreting data	**VOCABULARY:** aerodynamics, drag, lift, air pressure, specifications, researching, brainstorming, developing, building, testing, reflection, criteria, constraints, analyze **KEY TERMS:** band saw, drill press, hack saw, airflow, dragster, polyurethane, screw-eye	

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Unit III: Transportation Technology: Dragsters

NJ 2020 SLS: Science – Disciplinary Core Ideas 6-8 ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution **NJ 2016 SLS: Math** 6.RP.A.1 Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities **NJ 2016 SLS: Mathematical Practices** MP5: Use appropriate tools strategically		

ASSESSMENT EVIDENCE: Students will show their learning by:

- Preparing a detailed predesign for their dragster vehicle
- Preparing a spreadsheet for vehicle design materials
- Reflecting in an engineering journal that outlines daily completion tasks and technical evidence for design
- Performing a multistep process for constructing an efficient performance dragster
- Testing and competing against other groups in a Randolph Raceway Challenge

KEY LEARNING EVENTS AND INSTRUCTION:

- Shop equipment safety review
- Technical drafting of dragster
- Student modeling of constructed designs
- Daily reflection in engineering journal

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Unit III: Transportation Technology: Dragsters

SUGGESTED TIME ALLOTMENT	**3 weeks**
SUPPLEMENTAL UNIT RESOURCES	Required Supplies/Activities: Computers Band Saw Drill Press Dragster Balsa Blank Various Paint and Accessories Dragster Bundle Supplies Suggested Readings: https://theworks.org/wp-content/uploads/2019/08/TheWorksMuseum_Engineering-Design-Process_Poster.pdf https://auto.howstuffworks.com/auto-racing/motorsports/co2-powered-dragster.htm Suggested Supplies/Activities: “Dragster Pre-Design 1” “Dragster Pre-Design 2” “Dragster Pre-Design 3” “Using the Band Saw + Drill Press”

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APPENDIX A

Resources:

Text and Electronic Text:

None

Suggested Web Addresses:

www.google.com
www.tinkercad.com
http://www.physicsgames.net/game/Cargo_Bridge.html
http://www.pbs.org/wgbh/nova/tech/build-bridge-p3.html

Software Names:

Microsoft Word
Microsoft PowerPoint
Microsoft Excel
Internet Sources

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APPENDIX B

Rams Engineering Lecture

Grade Scale	Efficiency	Bridge Model	Creativity	Presentation Skills
5	Presentation displayed all of the necessary requirements AND research worksheet was complete.	Bridge Model represented an exact replica of the features of the bridge and was the correct size.	PowerPoint is quite unique while still being effective	Students were loud, spoke clearly, engaged the audience, and presented their material in a professional manner.
4	Presentation was lacking at most 2 requirements **AND** research worksheet was complete.	Bridge Model was the correct size, but was missing some key features of the actual bridge	The PowerPoint incorporates a lot of elements that makes it an effective presentation.	Students were loud and clear, however could have showed more professionalism while presenting
3	PowerPoint was lacking at most 4 requirements **OR** research worksheet was not complete.	Bridge Model was the correct size but represented a poor model of the actual bridge.	PowerPoint is an ordinary design, but still represents effective features.	Students were loud and spoke clearly. However, they did not engage the audience and were not professional.
2	PowerPoint was lacking at most 5 requirements **AND** research worksheet was not complete.	Bridge Model was not the correct size and represented a poor model of the actual bridge.	PowerPoint has only a few good elements within its structure.	Students were not loud or clear and did not present their material in a professional manner.
1	PowerPoint was missing more than 5 requirements **AND** research worksheet was not complete.	Bridge Model was not completed	PowerPoint is a poor design that clearly takes minimal effort to create.	Students were not professional at any point throughout the presentation.

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Truss Bridge Design

Grade Scale	Efficiency	Drawing Technique	Creativity	Drawing Relation
5	Bridge was able to withstand an excellent amount of kPa	Project represents excellent knowledge and use of drafting tools.	Bridge design is quite unique to common bridge designs found today, while still being effective	Bridge is an identical representation of the drawing that was created.
4	Bridge was able to withstand a fair amount of kPa.	Project represents fair knowledge and use of drafting tools.	The bridge incorporates a lot of effective design elements that makes it an effective design to utilize and build.	Bridge has only slight differences from the bridge drawing.
3	Bridge collapsed very quickly when a small amount of pressure was applied.	Project is drawn well, but it is apparent that drafting tools were not used in some spots of drawing.	Bridge is an ordinary design, but still represents effective features of common bridges today	Bridge has multiple parts that are different from the drawing that was created.
2	Bridge collapsed when a very little amount of pressure was applied to it.	Drawing is incomplete is some places, and the other parts were drawn hastily by hand.	Bridge has only a few good design elements within its structure, and it based upon a common design.	Bridge has many errors compared to how the drawing was created.
1	Bridge was unable to support itself standing.	Drawing was clearly done with little regard to the drafting techniques learned.	Bridge is a poor design that clearly takes minimal effort to create.	Bridge does a very poor job of representing the drawing.

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Projectiles in Motion

Grade Scale	Efficiency	Project Proposal Sheet	Creativity	Drawing Relation
5	Catapult was able to launch a Ping Pong ball a projectile distance of 20+ feet.	Project represents excellent knowledge and use of drafting tools and proper budgeting.	Project represents excellent knowledge and use of drafting tools and proper budgeting.	Project represents excellent knowledge and use of drafting tools and proper budgeting.
4	Catapult was able to launch a Ping Pong ball a projectile distance of 16-20 feet.	Project represents fair knowledge and use of drafting tools and proper budgeting.	Project represents fair knowledge and use of drafting tools and proper budgeting.	Project represents fair knowledge and use of drafting tools and proper budgeting.
3	Catapult was able to launch a Ping Pong ball a projectile distance of 12-16 feet.	Proposal is done well, but it is apparent that drafting tools were not used in some spots of drawing.	Proposal is done well, but it is apparent that drafting tools were not used in some spots of drawing.	Proposal is done well, but it is apparent that drafting tools were not used in some spots of drawing.
2	Catapult was able to launch a Ping Pong ball a projectile distance of 10-12 feet.	Proposal is incomplete is some places, and the other parts were drawn hastily by hand.	Proposal is incomplete is some places, and the other parts were drawn hastily by hand.	Proposal is incomplete is some places, and the other parts were drawn hastily by hand.
1	Catapult was able to launch a Ping Pong ball a projectile distance of less than 10 feet.	Proposal was clearly done with little regard to the techniques learned.	Proposal was clearly done with little regard to the techniques learned.	Proposal was clearly done with little regard to the techniques learned.

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Randolph Raceway

Design Checklist

1. Pre-Design Proposal 1
2. Pre-Design Proposal 2
3. Pre-Design Proposal 3 (Graph Paper- Scaled Drawing)
4. Prototype Creation/Re-Design Process
   Vehicle Design & Engineering Design Questions
5. Trace Side View onto Balsa Blank
6. Drill Axle Holes with Drill Press
7. Cut Side View with Band Saw
   Vehicle Design & Engineering Design Questions
8. Trace Top View onto Balsa Blank
9. Cut Top View with Band Saw
10. Dremel (if needed)
11. Sand with Sanding Block
    Vehicle Design & Engineering Design Questions
12. Paint Vehicle Design
13. Redrill Axle Hole with Drill Press
14. Cut Axle with Hack Saw
15. Select Wheels
16. Attach Wheels
17. Attach Screw Eyes by hand
18. Test for Driving
    Vehicle Design & Engineering Design Questions
19. RACE