Electrathon Car, CAAT

STEM Curriculum

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Curriculum Description

Overview

The Kent Career and Technical Center (KCTC) has developed a project-based curriculum that will revolves around the construction of a working electric powered vehicle (EPV) that will be entered into an Electrathon America race. This curriculum guides students through the design, build, test process with their electric powered vehicle. Curriculum experiences include a combination of classroom, lab learning, on-site work experiences, and exposure to emerging green career pathways. The curriculum developed will include mathematics and science standards for Physics, P1-P4, with an emphasis forces and motion, energy, and electricity for grades 9-12.

Units

Unit 1: Project Introduction

Lesson1 (U1L1) Electric Car Research

INDUSTRY PROBLEM
Become familiar with the Electric Car concept and components.

LEARNING PERFORMANCES/OUTCOMES
- Understand components at a macro level
- Characteristics of an electric powered vehicle
- Recognize design thinking tasks
- Identify positive and negative attributes of an electric car

DELIVERABLE
Students will create a preliminary electric design based on research.

LESSON TIMEFRAME
2-4 Hours total, time does not have to be divided equally among research and design. Some student will want to spend more time on one or the other.

TOPICS COVERED

SCIENCE	TECHNOLOGY	ENGINEERING	ART*	MATHEMATICS
– Force – Newton's Law	– Materials – Strength	– Manufacturing methods – Assembly – Cost constraints	– Aesthetics – Color	– Ratios – Proportions – Algebra of manufacturing processes – Algebra of building components

STANDARDS COVERED
- NGSS - Engineering Design HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4
- CCSS – Modeling with Geometry CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1
- Career and Technical Education Standards: 15.1306.2.11.B.1, 15.1306.2.11.B.2

MATERIALS NEEDED
- Internet access
- Printing
- Design Thinking process document printed
- Design Thinking journal

LESSON DIRECTIONS
Setup

- Research is done individually
- Setup groups to critic design proposals after research is complete. 3-5 students

Process

- Give students clear directions to what they are researching
- Guiding Questions
    a. What are the important characteristics of an electric car?
    b. What are some of the design constraints? How can they be overcome?
    c. What design characteristics can be reused?
    d. What design characteristics can be improved?
- Students record design observation in a journal
- Have students develop a concept drawing or list of components needed for an electric car
- Have students exchange design ideas in small groups, 3-5 students

Wrap-up

- What design ideas did the group have in common?
- What Ideas were unique?
- Identify changes in the design as a result of meeting with the group.
- Record design concepts in the journal.

Lesson2 (U1L2) NECA Car

INDUSTRY PROBLEM
Understand the parameters of the competition.

LEARNING PERFORMANCES/OUTCOMES

- Understand the event rules
- Understand the design rules

DELIVERABLE
Students will refine their design to meet NECA regulations.

LESSON TIMEFRAME
2-4 Hours.

TOPICS COVERED

SCIENCE	**T**ECHNOLOGY	**E**NGINEERING	**A**RT*	**M**ATHEMATICS
– Force – Newton's Law	– Materials – Strength	– Manufacturing methods – Assembly – Cost constraints	– Aesthetics – Color	– Ratios – Proportions – Algebra of manufacturing processes – Algebra of building components

STANDARDS COVERED • NGSS - Engineering Design HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4 • CCSS – Modeling with Geometry CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1 • Career and Technical Education Standards: 15.1306.2.11.B.1, 15.1306.2.11.B.2
MATERIALS NEEDED • Internet access • Printing • Design Thinking process document printed • Design Thinking journal • NECA – Electrathon America Handbook
LESSON DIRECTIONS *Setup* • Setup groups to critic design proposals after revising their designs. 3-5 students *Process* • Review and discuss the content of the handbook as a whole group. • Guiding Questions a. Identify what design criteria is affected by the NECA rules? b. How can the criteria be met? c. What design changes need to occur? • Students record design observation in a journal • Have students develop a concept drawing or list of components needed for an electric car • Have students exchange design ideas in small groups, 3-5 students *Wrap-up* • Identify changes in the design as a result of the rules. • Record design concepts in the journal.

Lesson3 (U1L3) Project Management

Standards (What can be assessed at the end of the grade or grade band) • ETS1A: Defining and Delimiting Engineering Problems. • ETS1B: Developing Possible Solutions • ETS1C: Optimizing the Design Solution

Learning Performances/Outcomes (Knowledge-in-Use)

Students will be able to:

- Apply their understanding of design the design process to manage project tasks and resources.
- Apply and understanding timelines and sequencing of tasks.

Industry Problem

- Managing a project with multiple tasks and resource requirements to meet project time lines and financial requirements.

Lesson Time Frame

2-6 hours, season recommendation: any

Materials Needed:

- Printed Student information sheet
- 1 Computer and projection system capable of playing Windows Media Videos and access to www.youtube.com.
- Computers capable of running online windows applications.

Narrative / Teacher Background Information (DCI)

To complete a project successfully, you must control a large number of activities, and ensure that they're completed on schedule.

If you miss a deadline or finish a task out of sequence, there could be knock-on effects on the rest of the project. It could deliver late as a result, and cost a lot more. That's why it's helpful to be able to see everything that needs to be done, and know, at a glance, when each activity needs to be completed.

Gantt charts convey this information visually. They outline all of the tasks involved in a project, and their order, shown against a timescale. This gives you an instant overview of a project, its associated tasks, and when these need to be finished.

Guiding Questions

- Has anyone been involved in a project with many different tasks needed to complete the project?
- Do projects typically have limited resources?
- How do you manage who does what task?
- Name some resources common to all projects?
- How do you manage the resources?

Assessment (What will be the evidence of learning?)

Pre-Test

Online assessment of project management.

Formative Assessment Create and submit a gantt chart. **Post-Test** Online assessment of project management.

Lesson Instructions
 	
• Prepare a gantt chart for student to work from.
  ○ Options:
    ▪ Paper and colored pencil charts.
    ▪ Microsoft Project
    ▪ Gantter Online free resource, www.gantter.com
• Have the students take the pre-test
• Watch the primary video, Project Management What is a Gantt Chart.
• Have students examine gantt chart examples
• Assign a project with a timeline that has multiple tasks and resources .
• Have students create and submit the gantt chart for the project.
• Students take the post test.

Lesson4 (U1L4) Enrichment Activity – Early Design Concepts

INDUSTRY PROBLEM Create several concept drawings
LEARNING PERFORMANCES/OUTCOMES (Knowledge-in-Use) • Develop critical thinking skills using the design thinking process. • Identify the value of variety of design concepts
DELIVERABLE Students will provide several different design concepts and highlight the differences and reasons for the differences.
LESSON TIMEFRAME 2-4 hours.

TOPICS COVERED

SCIENCE	TECHNOLOGY	ENGINEERING	ART*	MATHEMATICS
– Force – Newton's Law	– Materials – Strength	– Manufacturing methods – Assembly – Cost constraints	– Aesthetics – Color	– Ratios – Proportions – Algebra of manufacturing processes – Algebra of building components

STANDARDS COVERED

- NGSS - Engineering Design HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4
- CCSS – Modeling with Geometry CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1
- Career and Technical Education Standards: 15.1306.2.11.B.1, 15.1306.2.11.B.2

MATERIALS NEEDED

- List any required materials/tools here, include any suggestions on where teachers could come up with things they are unfamiliar with.
- Do we offer some tools, could they get them from old garages

LESSON DIRECTIONS

Setup

- Any organizing into groups necessary? Any pre-reading recommended? Watch intro video first?

Process

- What are the steps to completing the project and solving the problem?

Wrap-up

- Are there any guiding/ reflective questions needed to promote learning? Re-tie the lesson to standards and recommended outcomes. Complete post-assessment.

Unit 2: Safety Training

Lesson1 (U2L1) Shop Safety Rules

Document: Shop Safety Rules.pdf

Lesson2 (U2L2) Safety and First Aid

Document: AET_29_Safety_and_First_Aid.pdf

Unit 3: Electricity

Lesson1 (U3L1) Basics

Lesson plan 120.1

Objective: equip the future AET with foundational knowledge of series and parallel DC circuits so he or she will be able to perform procedurally and technically correct electrical service.

Driving question: What is a series circuit? What is a parallel circuit?

Outcomes: Student will be able to identify a series or parallel circuit on a wiring diagram, and state basic facts about parallel and series circuits.

Resources:

http://ncatt.org/_flash/voltage%20divider1.swf

http://ncatt.org/_flash/voltage%20divider2.swf

CES Labs 651 Lesson E-1 (Info sheets 3 and 4, and Experiments 2-4)

CES Labs 651 Lesson E-2 (Experiments 5-8)

CES Labs 651 Lesson G-4 (Info sheet 1 and Experiments 1-6)

Classroom discussion of FAA General Text Chapter 10 pp 10-34 through 10-43 covering:

1. Definitions
    a. Volts
    b. Ampere
    c. Resistance
    d. Ohm's Law
    e. Watts
    f. Power
    g. Joules
2. Circuit configurations
    a. Series circuit
    b. Parallel circuit
    c. Complex circuits
3. Effects of resistors
    a. Voltage drop
    b. In series circuit
    c. In parallel circuit
4. Laws
    a. Kirchhoff's Current Law
    b. Kirchhoff's Voltage Law

    c. Kirchhoff's Resistance Law
5. Bridge Circuits

Lesson plan 120.2

Objective: equip the future AET with foundational knowledge of troubleshooting and measurement techniques so he or she will be able to perform procedurally and technically correct electric service.

Driving question: What is a short circuit? What is an open circuit?

Outcomes: Student will be able to correctly identify a short and open circuit using a DMM.

Resources:

1. CES Labs 651 Lesson E-2 (Experiment 9-11)
2. CES Labs 651 Lesson G-3 (Experiments 1-4)
3. CES Labs 651 Lesson G-5 (Experiment 17)

Classroom discussion of FAA General Text Chapter 10 pp 10-82 through 10-90 covering:

1. Common problems
    a. Opens
    b. Shorts
2. Testing circuits using a multimeter and oscilloscope

Lesson plan 120.3

Objective: equip the future AET with foundational knowledge of troubleshooting and measurement techniques so he or she will be able to perform procedurally and technically correct electric service.

Driving question: How do you find and correct a short? How do you find and correct an open?

Outcomes: Student will be able to correctly identify a short and open circuit using a DMM.

Resources:

1. CES Labs 651 Lesson E-3 (Info sheet 7-8, and Experiments 17-18)
2. CES Labs 651 Lesson E-4 (Info sheet 9, and Experiments 19-27)

Lab only lesson. Get their hands on troubleshooting!

Unit 4: CAD

Lesson1 (U4L1) Basic CAD and Sketching

Students develop basic skills using Autodesk® SketchBook® Pro and Autodesk® 123D® Design as tools for product concept design. For this particular activity, students will develop a car. Automotive design is the profession involved in the development of the appearance, and to some extent the ergonomics, of car, vans, trucks, motorcycles, and coaches. Automotive design focuses on developing the visual appearance or aesthetics of the vehicle, though it is also involved in the creation of the product concept. Automotive design is practiced by designers who usually have an art background and a degree in industrial design or transportation design. The task of the designer or design team is usually split into three main aspects: exterior design, interior design, and color and trim design. Graphic design is also an aspect of automotive design. Automotive design focuses not only on the outer shape of automobile parts, but concentrates on the combination of form and function, starting from the vehicle package. The aesthetic value needs to correspond to ergonomic functionality and utility features as well.

Software: Autodesk® SketchBook® Pro and Autodesk® 123D® Design
Time: 1 to 5 hours
Difficulty: 1 Brain
Subject(s): Art, Math, Science, Engineering

Concepts Addressed
This project introduces students to the following concepts:

- Seven stages of Design Thinking.
- The importance of sketching in the ideation stage of Design Thinking.
- The value of digital sketching to quickly produce design concepts.
- The basics of 2 point perspective.
- The user interface and essential tools for Autodesk SketchBook Pro.
- The importance of layers in digital sketching.
- The use of color and shading to communicate 3D concepts.
- The user interface and essential tools for Autodesk 123D Design.
- Using sketches and primitives to create a digital model

Learning Objectives
After completing this project, students will be able to demonstrate growth in the following areas:

Process
Students will be able to:

Autodesk SketchBook Pro
- Navigate the user interface for Autodesk SketchBook Pro.
- Utilize a 2 point perspective grid to develop scaled perspective drawings.
- Develop perspective line drawings of a car using Autodesk SketchBook Pro.
- Utilize variations in line width and opacity in the design of a car.
- Utilize layers in order to create multiple versions of a design.
- Utilize fill and brush tools to quickly color and shade multiple versions of a design.

Autodesk 123D Design
- Navigate the user interface for Autodesk 123D Design.
- Create the base car parts using sketch tools and primitives.
- Create 3D models using the construct tools such as extrude.
- Utilize modify tools such as fillet.

- Add context to the car design using the supplied material finishes.
- Pattern existing 3D models.
- Insert pre-built parts from Kits.

Academic Content
Students will be able to:
- Apply their understanding of Design and Technology for the design of a car.
- Apply an understanding of mathematic scale to the design of a car.
- Apply an understanding of 3 dimensional measurements.
- Explain the importance of conceptual design in the product development process.

Key Terms: Autodesk SketchBook Pro

Brush is a tool for adding brushstrokes to the canvas. Available brushes include pencil, pen, eraser, paintbrush, airbrush, marker, chisel brush, felt pen, and smear pen.

Brush Editor is a window with two panels, one for choosing brushes and changing their attributes.

Canvas is the paintable area where strokes are applied and images are imported.

Color Editor provides options for selecting, creating and making changes to colors.

Lagoon *is a* repositionable palette of Sketchbook Express tools; the same tools can also be accessed through the windows menu.

Layer is an entity that contains its own content. When combined or stacked with other layers, it becomes part of a composition. Layers can be visible or hidden, rearranged, transformed, their opacity changed, and blended.

Opacity is the amount of transparency. Paint/brush and layer opacity can be changed.

Perspective-2 point is a graphics technique used to describe three dimensional objects on a 2 dimensional surface. In 2 point perspective parallel lines converge towards two vanishing points. Vertical lines remain vertical.

Perspective Grid *is a* drawing aid used to develop drawings in perspective.

Pixel is a term that defines small little dots that form the images on computer displays. Tool sizes such as the width of a brush stroke are defined by the number of pixels.

Product Sketch is a rough drawing primarily used to develop concepts for further refinement.

Puck *is* a circular floating pallet with tools for screen navigation and manipulation of images and layers to control elements such as size, scale, and location on the canvas.

Redo is a command that allows the user to return to a previous action that had previously been removed through the Undo command.

Scale Drawing is a drawing of an object where all parts are in the same proportion of their actual size but usually drawn at a much smaller size to for on paper or a digital canvas.

Shading is creating the impression of 3 dimensions through the use of gradations of light and color in a sketch.

Transparency (of layer, of brush) is the amount of detail you can see underneath a layer or brushstroke.

Undo is a command that allows the user to remove to 30 of the last actions taken in Autodesk SketchBook Pro.

Key Terms: Autodesk 123D Design

Gallery contains examples of models completed in 123D Design.

Groups contain one or more objects, as well as other groups.

Intelligent Snapping allows a 2D or 3D primitive to be dragged onto any geometry and snap to the nearest face or edge.

Kits contains custom parts and pre-built kits.

Navigation Tools used to move around the scene. These include, pan, orbit, and zoom.

Patterns create circular, rectangular, path, and mirrored patterns.

Redo is a command that allows the user to return to a previous action that had previously been removed through the Undo command.

Select Based Options displays only the relevant options based on the selected 2D or 3D primitive.

Undo is a command that allows the user to remove to 30 of the last actions taken in Autodesk 123D Design.

View Cube used to look at and orbit around the scene.

Guiding Questions

- What is the most popular scale for these cars?
- Some cars are powered by electric motors and others by gas. Compare the advantages and disadvantages of each power source.
- What are the key green design principles that should be considered? For example how many batteries are required to power an electric car and can the batteries be recycled?
- How would factors such as age of the user, and boy or girl impact the design?

Project Outline
Project Assets: Autodesk SketchBook Pro

- Technical Video Car Design Part 3 – Sketch the Wheels and the Outline
  Create an ISO sketch of the wheels and outline of the car body.
- Technical Video Car Design Part 4 – Highlight the Sketch
  Use the felt tip pen and airbrush to highlight the outline of the car and add shadows.
- Technical Video Car Design Part 5 – Add Paint and Shadows
  Complete the sketch of the car using the airbrush to simulate paint and sunlight.

Project Instructions: Autodesk SketchBook Pro

- Open Autodesk SketchBook Pro.

- View the Part 1 and Part 2 videos on the user interface and layers / grid from the Balance Bike project (optional, as review)
- Complete the sketch of the car tutorial. (Technical Videos Parts 3 through 5).

Autodesk SketchBook Pro Datasets

Required Datasets:

None

Supplied Datasets:

Car.tif - The completed sketch. Layers can be hidden to demonstrate the phases of the project.

Project Assets: Autodesk 123D Design

- Technical Video Car Design Part 3 – Create the Car Profile Shapes
  Use polylines and splines to create side and rear profiles of the car.
- Technical Video Car Design Part 4 – Model the Car Body
  Use the extrude intersect option to convert the profiles into the body of the car.
- Technical Video Car Design Part 5 – Model the Wheel Openings
  Sketch and extrude the 4 wheel openings.
- Technical Video Car Design Part 6 – Add the Wheels
  Open a wheel from Kits and modify to match the scale of the car body.

Project Instructions: Autodesk 123D Design

- Open Autodesk 123D Design.
- View the Part 1 and Part 2 videos on the user interface and making parts from the Balance Bike project (optional, as review)
- Complete the sketch of the car tutorial. (Technical Videos Parts 3 through 6).

Autodesk 123D Design Datasets

Required Datasets:

None

Supplied Datasets:

CarWheel.123dx - Completed wheel. This file can be used for demonstrations or supplied to students who have not completed this phase of the project.

Car.123dx - Completed bike. This file can be used for demonstrations or supplied to students who have not completed this phase of the project.

When all tutorials are completed, encourage students to develop their own car design ideas.

Differentiated Instruction

- Encourage students to review the lesson and skills videos in small groups.
- Have small teams of students collaborate to complete one design criteria matrix by dividing up the work.
- Identify specific websites that students can use for the Define and Explore stages.
- Provide some students with a set of predefined design criteria and background content to modify the Define and Explore stages.
- Have small groups collaborate on the Ideate, Refine, Prototype, and Presentation stages. Have some students focus on the development of physical sketches and sketch models while collaborating with team members who focus on digital prototyping.
- Provide students with self and peer evaluation forms to be filled out at the completion of each phase.
- Provide students with models of successful student presentations with clear examples of each Design phase.

Non-Native Speakers

- Encourage students to tap into their own culture and life experience to discover prior knowledge of the project topic.
- Provide English/first language translation dictionaries and/or electronic translation devices.
- Allow the student to prepare materials in their primary language and have it translated later.
- Pair ELL students with native English speakers.
- Provide a translator for viewing of videos.

Special Needs Students

- Provide prefabricated modeling components.
- Engage the help of aides to assist in physical sketch modeling and prototypes.
- Accommodate students by allowing additional time and/or reducing the scope of project requirements.
- Provide any necessary accommodations for access to technology such as alternative input devices, larger font sizes, speech recognition, and so on.

STEAM Connections
Science

- Car manufacturers are looking at alternate power sources including; hydrogen, electric, and hybrid versions that use both combustion engines and electric power. The primary goal is to design vehicles that consume less gasoline, yet maintain the consumer's desire for dynamic performance. There is much debate about the impact these vehicles are having with regards to improving fuel consumption, and consequently reducing emissions. Identify manufacturers who are building cars powered by hydrogen, electric, and hybrid. Then research the claims of each manufacturer as to why their system is the best design.

Technology

- Electric cars powered by batteries or hybrid systems use one of three battery types; lead-acid, nickel-metal hydride (NiMH) and lithium-ion (Li-ion). Review each of these battery types and the impact on the environment when they are no longer working.

Engineering

- In addition to the introduction of different power sources, car manufacturers are looking to lighter materials in the construction of cars. Aluminum and carbon fiber are just 2 of the materials being used to replace heavier steel parts. These materials do reduce the overall weight of the car and improve the efficiency of the car. However, the initial gains are offset by downstream issues such as repair costs to aluminum and carbon fiber body panels. Compare and contrast the issues around the introduction of materials such as aluminum. The topics for discussion should include, reduction of fuel consumption, cost of repairing steel panels versus aluminum versus carbon fiber, and the impact on the natural resources required for steel, aluminum and carbon fiber.

Art

- The design of a new car takes many months and sometimes years to complete. Designers use pencil sketches, sketching software such as SketchBook Pro, clay models and digital prototypes to create their conceptual designs before resources are spent on making the actual car. However, when you ask people what the best car designs are they often include designs from an era when sketching and clay models were the only tools available. Research cars through the ages and based on that create a list of the 10 cars considered to be the best designs, regardless of when they were designed.

Unit 5: Mechanical Systems

Lesson1 (U5L1) Power Transmission

INDUSTRY PROBLEM
Electric Car Research

LEARNING PERFORMANCES/OUTCOMES (Knowledge-in-Use)

Explain the purposes and applications of cams.
Describe the three main types of cam motion.
Develop a cam related displacement diagram and profile.
Describe the information needed for a typical gear drawing.
Draw gear teeth using the simplified board drafting method.
Create a gear-tooth drawing.

DELIVERABLE
Drawings and calculations of gears for the Electrathon car.

LESSON TIMEFRAME
4-6 hours

TOPICS COVERED

SCIENCE	**T**ECHNOLOGY	**E**NGINEERING	**A**RT*	**M**ATHEMATICS
– Force – Newton's Law	– Materials – Strength	– Manufacturing methods – Assembly – Cost constraints	– Aesthetics – Color	– Ratios – Proportions – Algebra of manufacturing processes – Algebra of building components

*Artistic thought is a necessary part of the design process; this section is included to demonstrate that idea.

STANDARDS COVERED

ELA: Apply strategies to interpret texts (NCTE) Use written language to communicate eff ectively (NCTE)
Mathematics:
Measurement Understand measurable attributes of objects and the units, systems, and processes of measurements (NCTM)
Measurement Apply appropriate techniques, tools, and formulas to determine measurement (NCTM)
Industry Standards:
Machinery/Mechanism Drafting (ANSI/ASME Y14)

MATERIALS NEEDED

- Computer Aided Design System
- Or Drafting equipment, board, T square, Triangle, Pencils, Compass

LESSON DIRECTIONS

Setup

- Assign equipment

Process

- Complete exercises in Chapter 17, 1-14 of the Mechanical Drawing text.

Wrap-up

- Complete Post test

Lesson2 (U5L2) Steering

INDUSTRY PROBLEM
Design an efficient steer system that meets NECA regulations

LEARNING PERFORMANCES/OUTCOMES

- Identify forces on steering systems
- Applied physics

DELIVERABLE
Analysis of forces on the Electrathon car steering system.

LESSON TIMEFRAME
4-6 hours

TOPICS COVERED

SCIENCE	TECHNOLOGY	ENGINEERING	ART*	MATHEMATICS
– Force – Newton's Law	– Materials – Strength	– Manufacturing methods – Assembly – Cost constraints	– Aesthetics – Color	– Ratios – Proportions – Algebra of manufacturing processes – Algebra of building

				components

**Artistic thought is a necessary part of the design process; this section is included to demonstrate that idea.*

STANDARDS COVERED

- NGSS: HS-PS2-1, HS-PS2-2, HS-PS2-3, HS-PS2-4, HS-PS2-5, HS-ETS1-1 HS-ETS1-2, HS-ETS1-3, HS-ETS1-4
- CCSS: Modeling with Geometry CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1

MATERIALS NEEDED

- Calipers
- Tape measure
- Force scale
- Camber presentation
- Cardboard and/or wood

LESSON DIRECTIONS

Setup

- Layout measurement equipment

Process

- Students measure frame
- Create preliminary steering system design
- Prototype the steering, cardboard, wood, 3D printing
- Group decision on final design
- Fabricate parts

Wrap-up

- Test final system

Lesson3 (U5L3) Acceleration and Braking

INDUSTRY PROBLEM

Determine force and time required for braking.

LEARNING PERFORMANCES/OUTCOMES (Knowledge-in-Use)

- Understand mathematic representation of acceleration and braking.

DELIVERABLE

Calculation worksheet representative of Electrathon car perameters.

LESSON TIMEFRAME

2-4 hours

TOPICS COVERED

SCIENCE	**T**ECHNOLOGY	**E**NGINEERING	**A**RT*	**M**ATHEMATICS
– Force – Newton's Law	– Materials – Strength	– Manufacturing methods – Assembly – Cost constraints	– Aesthetics – Color	– Ratios – Proportions – Algebra of manufacturing processes – Algebra of building components

**Artistic thought is a necessary part of the design process; this section is included to demonstrate that idea.*

STANDARDS COVERED

Standards for Technology Literacy

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

National Science Education Standards
Grades 5-8 Science as Inquiry

- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Use technology and mathematics to improve investigations and communications.
- Think critically and logically to make the relationships between evidence and explanations.
- Formulate and revise scientific explanations and models using logic and evidence.

Grades 9-12 Physical Science Content Standard B
<u>Motion and Forces</u>:

- Its position, direction of motion and speed can describe the motion of an object. That motion can be measured.
- If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.

Grades 9-12 Science as Inquiry

- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Motion and forces: Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects.

MATERIALS NEEDED

- List any required materials/tools here, include any suggestions on where teachers could

come up with things they are unfamiliar with.
- Do we offer some tools, could they get them from old garages

LESSON DIRECTIONS
Setup
- Any organizing into groups necessary? Any pre-reading recommended? Watch intro video first?

Process

Activity 1: Calculating Reaction Time
Activity 2: Calculating Braking Distance

Activity 3: Setting Yellow Light Time

Activity 4: Programming Logic For Traffic Systems

Activity 5: Reactive Traffic Technology

Wrap-up
- Posttest for braking

Unit 6: Electrical System

Lesson1 (U6L1) Batteries / Motor

INDUSTRY PROBLEM
How much work will be powered by 2 car batteries

LEARNING PERFORMANCES/OUTCOMES (Knowledge-in-Use)
- Battery power curves
- Motor power consumption
- Motor controllers role

DELIVERABLE
Calculation worksheets showing energy use.

LESSON TIMEFRAME
6-10 hours

TOPICS COVERED

SCIENCE	TECHNOLOGY	ENGINEERING	ART*	MATHEMATICS
– Force – Newton's Law	– Materials – Strength	– Manufacturing methods – Assembly – Cost constraints	– Aesthetics – Color	– Ratios – Proportions – Algebra of manufacturing processes – Algebra of building components

**Artistic thought is a necessary part of the design process; this section is included to demonstrate that idea.*

STANDARDS COVERED
• NGSS - Engineering Design HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4 • CCSS – Modeling with Geometry CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1 • Career and Technical Education Standards: 15.1306.2.11.B.1, 15.1306.2.11.B.2
MATERIALS NEEDED • Battery power curve diagrams • Motor specifications • Motor controller handbook • Multimeter
LESSON DIRECTIONS ***Setup*** • Organize lab equipment to measure power • Attach motor and batteries to bench *Process* • Measure battery voltage/amps • Run the motor from batteries for 15-30 minutes • Calculate work • Measure battery voltage/amps • Repeat process running the motor until the battery is completely drained. *Wrap-up* • Compare the results of the test and the power curves

Lesson2 (U6L2) Motor Controller

INDUSTRY PROBLEM
Manage power efficiently
LEARNING PERFORMANCES/OUTCOMES (Knowledge-in-Use) • Recognize optimum performance characteristics
DELIVERABLE Program motor controller for optimum performance
LESSON TIMEFRAME 6-10 hours
TOPICS COVERED

SCIENCE	TECHNOLOGY	ENGINEERING	ART*	MATHEMATICS
– Force – Newton's Law	– Materials – Strength	– Manufacturing methods – Assembly – Cost constraints	– Aesthetics – Color	– Ratios – Proportions – Algebra of manufacturing processes – Algebra of building components

**Artistic thought is a necessary part of the design process; this section is included to demonstrate that idea.*

STANDARDS COVERED

- NGSS - Engineering Design HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4
- CCSS – Modeling with Geometry CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1
- Career and Technical Education Standards: 15.1306.2.11.B.1, 15.1306.2.11.B.2

MATERIALS NEEDED

- Windows PC
- Motor controller communications cable
- Motor controller software

LESSON DIRECTIONS

Setup

- Install and configure motor controller software and communication cable

Process

- Test the built in configurations with the batteries and motor
- Compare the results of the different configurations
- Design and optimal power control diagram from the gather results
- Upload the final program to the controller
- Test the power used with the new configuration for an hour.
- Compare results to the default.
- Repeat the process until the group agrees that the system has reached an optimal performance.

Wrap-up

- Are there any guiding/ reflective questions needed to promote learning? Re-tie the lesson to standards and recommended outcomes. Complete post-assessment.

Appendix

NGSS, Next Generation Science Standards

HS-ETS1 Engineering Design

HS-ETS1 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.

- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2)
- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence,

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)

Crosscutting Concepts

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)

Connections to Engineering, Technology, and Applications of Science

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

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)

prioritized criteria, and tradeoff considerations. (HS-ETS1-3)		
Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems include: **Physical Science:** HS-PS2-3, HS-PS3-3 Connections to HS-ETS1.B: Designing Solutions to Engineering Problems include: **Earth and Space Science:** HS-ESS3-2, HS-ESS3-4, **Life Science:** HS-LS2-7, HS-LS4-6 Connections to HS-ETS1.C: Optimizing the Design Solution include: **Physical Science:** HS-PS1-6, HS-PS2-3		
Articulation of DCIs across grade-bands: **MS.ETS1.A** (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4); **MS.ETS1.B** (HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4); **MS.ETS1.C** (HS-ETS1-2),(HS-ETS1-4)		
Common Core State Standards Connections: ELA/Literacy – **RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3) **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3) **RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3) Mathematics – **MP.2** Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.4** Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4)		