STEM Curriculum Planning Guide

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

STEM Unit Title	**Who You Gonna Call? Mousebusters!**
Economic Cluster	Sensors
Targeted Grades	7th-8th
STEM Disciplines	Science, Technology, Engineering, and Mathematics
Non-STEM Disciplines	English Language Arts, Social Studies, Fine Arts

Section I: STEM Unit Overview

Unit Overview

Disruptive and harmful pests are a nuisance and becoming more of a problem as humans continue to develop land that was once their home. Exterminators and pest control professionals need to continue to develop new and humane ways to trap and relocate these critters.

This unit's focus is the design of an effective and humane animal trap that could be used on a variety of animals. Students will utilize their gained knowledge of forces (electrical, magnetic, and gravitational) through teacher demonstrations, models, multimedia presentations, and hands on activities to implement one or more forces in their final design. Final designs will be tested using various sizes of motorized animals to simulate diversity of life.

Essential Question

How can forces work individually or in combination to solve a real-world problem?

Enduring Understanding

Magnetic, electrical, and gravitational forces can act at a distance between objects.
Field models can show how objects exert force on each other without touching.
Provide support of conclusions based on results of engineering design challenge.
Equations can be used to describe data collected and the results can be graphed.

Engineering Design Challenge

Build a (humane) mouse trap using gravitational, magnetic, and/or electric forces.
Students will be assigned a type of animal and number of forces that must be used in the trap design. Students will design, build, and test a trap that uses the number of forces assigned to humanely trap the animal (minimal contact with animal). Depending on the results of the trap testing of the original design, the students will redesign and re-test to meet the original performance criteria or maintain performance while reducing the cost of the design. Students will create detailed sketches of original and redesigned traps (including dimensions) and bill of materials (cost of raw materials to make the trap) for the original and redesign and calculate cost reduction. Students will present and defend original and redesigned traps; bill of materials and reduction of cost.

Time and Activity Overview

Day	Time Allotment	Actvities
1	50 minutes	Pre-Test and Hook
2	50 minutes	Introduction to Forces
3	50 minutes	Introduction to Forces: Gravitational Forces
4	50 minutes	Introduction to Forces: Circuit Stations
5	50 minutes	Introduce Engineering Design Challenge -- Electromagnetic Stations
6	50 minutes	Introduce Engineering Design Challenge -- Build
7	50 minutes	Engineering Design Challenge -- Build
8	50 minutes	Engineering Design Challenge -- Build
9	50 minutes	Engineering Design Challenge -- Testing and Redesign

10	50 minutes	Engineering Design Challenge -- Redesign; Presentations
11	50 minutes	Presentations; Post-Test

Academic Content Standards

Pre-requisite Knowledge & Skill	Scale factor Simple circuits (how they work, open/close) Basic understanding of how energy changes form Basic data graphing

Add Standard	Mathematics
Grade/Conceptual Category	7
Domain	Probability and Statistics
Cluster	
Standards	Use random sampling to draw inferences about a population Draw informal comparative inferences about two populations

Add Standard	Mathematics
Grade/Conceptual Category	7
Domain	Expressions and Equations
Cluster	
Standards	Use properties of operations to generate equivalent expressions Solve real-life and mathematical problems using numerical and algebraic expressions and equations

Add Standard	English Language Arts
Grade	CCSS.ELA-Literacy.RST.6-8.1
Strand	Science & Technical Subjects
Topic	Key Ideas and Details
Standard	Cite specific textual evidence to support analysis of science and technical texts.

Add Standard	English Language Arts
Grade	CCSS.ELA-Literacy.RST.6-8.2
Strand	Science & Technical Subjects
Topic	Key Ideas and Details
Standard	Determine the central ideas of conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

Add Standard	English Language Arts
Grade	CCSS.ELA-Literacy.RST.6-8.3
Strand	Science & Technical Subjects
Topic	Key Ideas and Details
Standard	Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks.

Add Standard	English Language Arts	
Grade	CCSS.ELA-Literacy.RST.6-8.7	
Strand	Science & Technical Subjects	
Topic	Integration of Knowledge and Ideas	
Standard	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).	

Add Standard	English Language Arts	
Grade	CCSS.ELA-Literacy.RST.6-8.8	
Strand	Science & Technical Subjects	
Topic	Integration of Knowledge and Ideas	
Standard	Distinguish among facts, reason judgment based on research findings, and speculation in a text.	

Add Standard	English Language Arts	
Grade	CCSS.ELA-Literacy.RST.6-8.9	
Strand	Science & Technical Subjects	
Topic	Integration of Knowledge and Ideas	
Standard	Compare and contrast the information gained from experiments, simulations, video or multimedia sources with that gained from reading a text on the same topic.	

Add Standard	Social Studies	Ohio
Grade	7	
Theme	World Studies from 750 B.C. to 1600 A.D.: Ancient Greece to the First Global Age	
Strand (pk-8 only)	Government	
Topic	Civic participation embraces the ideal that an individual actively engages in his or her community, state or nation for the common good. Students need to practice effective communication skills including negotiation, compromise and collaboration. Skills in accessing and analyzing information are essential for citizens in a democracy.	
Content Standard	The ability to understand individual and group perspectives is essential to analyzing historic and contemporary issues.	

Add Standard	Science	Ohio
Grade	8	
Theme	Order and Organization	
Topic	Physical Science: Forces and Motion	
Content Standard	Forces between objects act when the objects are in direct contact or when they are not touching. Magnetic, electrical and gravitational forces can act at a distance. A field model can be used to explain how two objects can exert forces on each other without touching. An object is thought to have a region of influence, called a field, surrounding it. When a second object with an appropriate property is placed in this region, the field exerts a force on and can cause changes in the motion of the object. Electric fields exist around objects with charge. If a second object with charge is placed in the field, the two objects experience magnetic forces that can attract or repel them, depending on the objects involved. Magnetic force weakens rapidly with increasing distance. Magnetic field lines can be seen when iron filings are sprinkled around a magnet. Gravitational fields exist around objects with mass. If a second object with mass is placed in the field, the two objects experience attractive gravitational forces toward one another. Gravitational force weakens rapidly with increasing distance. Every object exerts a gravitational force on every other object with mass. These forces are hard to detect unless at least one of the objects is very massive (e.g.., sun, planets). The gravitational force increases with the mass of the objects, decreases rapidly with increasing distance and points towards the center of objects. Weight is a gravitational force and is often confused with mass. Weight is proportional to mass, but depends upon the gravitational field at a particular location. An object will have the same mass when it is on the moon as it does on Earth. However, the weight (force of gravity) will be different at these two locations. Electricity is related to magnetism. In some circumstances, magnetic fields can produce electrical currents in conductors. Electric currents produce magnetic fields. Electromagnets are temporary magnets that lose their magnetism when the electric current is turned off. Building an electromagnet to investigate magnet properties and fields can demonstrate this concept.	

Add Standard	Science	Ohio
Strand		
Course Content		
Content Elaboration		

Add Standard	Fine Arts	Ohio
Enduring Understanding	Critical and Creative Thinking: Students combine and apply artistic and reasoning skills to imagine, create, realize and refine artworks in conventional and innovative ways. Authentic Application and Collaboration: Students work individually and in groups to focus ideas and create artworks that address genuine local and global community needs.	
Progress Points	E. Form and express opinions about artworks and apply critical and creative thinking skills to assess and refine their artworks.	
Grade Level	8	
Content Statement	2PR- Demonstrate increased technical skill and craftsmanship by using more complex processes and materials to design and create two- and three-dimensional artworks.	

Add Standard	Fine Arts	Ohio
Enduring Understanding	Critical and Creative Thinking: Students combine and apply artistic and reasoning skills to imagine, create, realize and refine artworks in conventional and innovative ways. Authentic Application and Collaboration: Students work individually and in groups to focus ideas and create artworks that address genuine local and global community needs.	
Progress Points	E. Connect the content of visual artworks to interdisciplinary concepts, issues and themes.	
Grade Level	7	
Content Statement	1PR Improve craftsmanship and refine ideas in response to feedback.	

Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

Performance Task, Projects	Engineering Design Challenge (Appendix N) Engineering Design Challenge Rubric (Appendix O) Bill of Materials (Appendix P) Data Collection (Appendix S) Design Scalability (Appendix T) Student-generated Designs
Quizzes, Tests, Academic Prompts	Pre-Test (Appendix A) Post-Test (Appendix A) The Hook (Appendix C) Image Response Worksheet (Appendix D) Cartoon Clips Activity (Appendix E)
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	Presentation (Appendix Q) Gravitational Forces Activity (Appendix H) Electrical Force and Circuit Stations (Appendix J) Electromagnetic Stations (Appendix K)
Student Self- Assessment	Code of Cooperation (Appendix F) Career Roles (Appendix G)

Technology Integration

ADISC Technology Integration Model*

	Type of Integration	Application(s) in this STEM Unit
A	Technology tools and resources that support students and teachers in ***adjusting, adapting, or augmenting*** teaching and learning to meet the needs of individual learners or groups of learners.	Teachers will use a Smartboard or LCD projector to view a YouTube video on Billy the Exterminator.
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	Students may use graphing calculators to solve mathematical concepts and plot data. Students will use a multimeter and a light meter to measure voltage and light output.
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	Students will use search engines to conduct research.
S	Technology tools and resources that support students and teachers in ***simulating*** real world phenomena including the modeling of physical, social, economic, and mathematical relationships.	Students will view YouTube videos clips to identify forces and mechanisms used in traps.
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	Students may use a PowerPoint or Prezi to communicate design of trap with class.
	**The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton*	

Career Connections

Career Description

Agricultural engineers—also known as biological and agricultural engineers—work on a variety of activities, from aquaculture (raising food, such as fish, that thrive in water) to land farming to forestry; from developing biofuels to improving conservation; from planning animal environments to finding better ways to process food. In this lesson, an agricultural engineer would combine their knowledge about animals and mechanical design to provide input to the trap design; review and analyze results of testing; and offer suggestions to the trap redesign based on the testing results. http://www.bls.gov/ooh/architecture-and-engineering/agricultural-engineers.htm#tab-1

Design engineers research and develop ideas for new products and the systems used to make them. They work in a variety of industries, ranging from electronics to synthetic textiles, on projects as diverse as the redesign of a mobile phone to the construction of motorcycle parts from composite materials. Many design engineers have degrees in Mechanical Engineering. In this lesson, the design engineer would work with experts in materials and biology to design the humane trap; sketch the trap; lead the build and test of the trap; review and analyze results of testing; and redesign the trap based on the testing results.https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/designengineer.aspx

Electrical engineers design, develop, test, and supervise the manufacturing of electronic components, software, products, or systems for commercial, industrial, medical, military, or scientific applications. They analyze customer needs and determine electrical system requirements, capacity, and cost to develop a system plan. They work on a variety of electrical equipment, such as electric motors, radar and navigation systems, global positioning systems (GPS), communications systems, computer hardware,and electrical systems for automobiles and aircraft. In this lesson, an electrical engineer would provide detailed information about how the forces work, how to incorporate the forces into the trap design, and ensure that it performs as designed; review and analyze results of testing; and offer suggestions to the trap redesign based on the testing results. http://www.bls.gov/ooh/architecture-and-engineering/electrical-and-electronics-engineers.htm#tab-1

Materials engineers develop, process, and test materials used to create a range of products, from computer chips and aircraft wings to golf clubs and snow skis. They also help select materials and develop new ways to use materials. In this lesson, a materials engineer would select materials to meet the performance and cost requirements for the trap design; review and analyze results of testing; and offer suggestions to the trap redesign based on the testing results.http://www.bls.gov/ooh/architecture-and-engineering/materials-engineers.htm

Mechanical engineers analyze problems to see how mechanical and thermal devices might help solve the problem; design or redesign mechanical and thermal devices using analysis and computer-aided design; develop and test prototypes of devices they design; and analyze the test results and change the design as needed. Mechanical engineering is one of the broadest engineering disciplines with many different job opportunities. In this lesson, a mechanical engineer would provide detailed information about how to incorporate the forces into the trap design and ensure that it performs as designed; review and analyze results of testing; and redesign the trap based on the testing results. http://www.bls.gov/ooh/architecture-and-engineering/mechanical-engineers.htm#tab-1

Systems engineers design and coordinate large and complex projects known as systems. A system has many parts that all interact extensively with one another. For example, a jet airliner can be a system. So, too, can all of the airplanes owned by one airline. All of the airplanes in a country make up a more extensive system. An even larger and more complex system includes all of a nation's transportation facilities. Systems engineers can work at various levels in the design and coordination of these systems. In this lesson, a systems engineer would incorporate information from experts in materials, biology and design to ensure that the trap performed as designed; lead the build and test of the trap; review and analyze results of testing; and redesign the trap based on the testing results. http://careers.stateuniversity.com/pages/419/Systems-Engineer.html

Project Managers manage projects and project teams to meet the technical objectives of the project on-time and on-budget. Projects have a defined beginning and end in time, and therefore defined scope of work and resources. The development of software for an improved business process, the construction of a building or bridge, the relief effort after a natural disaster, the expansion of sales into a new geographic market are all examples of projects. Almost every industry has project managers. It is a common career path for all engineering majors. In this lesson, a project manager would lead the project, ensuring that all deliverables are complete and acceptable; ensure that each team member had the resources they needed to accomplish their assigned job; communicate results and project status to all team members and to customer (project presentation); ensure the trap design met the design criteria. http://www.pmi.org/About-Us/About-Us-What-is-Project-Management.aspx

Zoologists and wildlife biologists study animals and other wildlife, and how they interact with their ecosystems. They study the physical characteristics of animals, animal behaviors, and the impacts humans have on wildlife and natural habitats. For example, they take blood samples from animals to assess their levels of nutrition, check animals for disease and parasites, and tag animals in order to track them. They also work closely with public officials to develop wildlife management and conservation plans that protect species from threats and help animal populations return to and remain at sustainable levels. In this lesson, a zoologist or wildlife biologist would provide detailed information about the animal for the trap design; review and analyze results of testing; and offer suggestions to the trap redesign based on the testing results. http://www.bls.gov/ooh/life-physical-and-social-science/zoologists-and-wildlife-biologists.htm#tab-1

Section II: STEM Lesson Plan

Title of Lesson — **Day 1 -- Pre-Test and Hook**

Time Required — 50 minutes

Materials

Projector with Internet access
Calculator
Appendix A

Objectives

Students will engage in a diagnostic assessment and activate prior knowledge regarding forces that can act at a distance.

Instructional Process

1. Students will take the pre-test at the beginning of class.

2. The Hook: Begin by showing this short clip to your students: https://www.youtube.com/watchv=_uYwjK2GluM take from A&E's Billy the Exterminator. Ricky talks about his less than fortunate encounter with a gopher and run-ins with several other animals.

3. Break students into small teams (ideally 4 students per team). Distribute the hook worksheet (Appendix C) with the animals given.

4. With about 5-10 minutes left in class, have one spokesperson from each team present what they know, what they need to know, and what their plan is to humanely trap one animal.

Differentiation

Modifications can be made to the student sheets in Appendix C. For students that may require additional prompting, scaffolding can be added.

Assessments

Pre-Test (Appendix A)
Student Hook Handout (Appendix C)

Section II: STEM Lesson Plan

Title of Lesson

Day 2: Introduction to Forces

Time Required

50 minutes

Materials

Computer with Internet Access
Career Roles Worksheet (Appendix G)
Code of Cooperation Worksheet (Appendix F)
Video Clip Activity Worksheet (Appendix E)
Image Response Worksheet (Appendix D)

Objectives

Students will be introduced to forces (gravitational, electrical, and magnetic).

Students will use images to begin thinking about different types of closures to use in their trap design.

Instructional Process

1. Explain to students that today they will be introduced to different forces that will be elaborated on throughout the unit and ultimately used in the design of their trap. Additionally students will work with their team members to assign Career Roles and create a code of cooperation.

2. Distribute and discuss descriptions of Career Roles. Allow time for teams to choose individual roles. Discuss with students the importance of understanding the selected role as they will be responsible for that role throughout the project. Please refer to the career connections section for additional career details to facilitate the discussion.

3. Distribute code of cooperation worksheet. Explain to students the importance of cooperating with a team. Have teams complete worksheet

4. Video Clip Activity - Open the following video clips on computer and project onto screen. Each clip shows a force as well as a mechanism for trapping. Students will identify the force and describe the mechanism after each clip, using the provided worksheet. Allow Time for students to complete the worksheet after each clip. Note: Websites may need to be sent to your building's technology coordinator prior to the start of the lesson for them to be unblocked.

a. https://www.youtube.com/watch?v=XFvoRexxA2Y - Bugs and Wile E.
b. https://www.youtube.com/watch?v=hz65AOjabtM - Wile E all alone
c. https://www.youtube.com/watch?v=VvGowdP-zYg - Batman (stop after 53 seconds)
d. https://www.youtube.com/watch?v=0iP8WjXE3FU - Tom and Jerry
e. https://www.youtube.com/watch?v=bkAVL8W8tyl - Spiderman (19.25-20.00)

5. Image Response Activity - Distribute Image Response Activity Worksheet. Instruct students to view each image. With their team, students should discuss how each image would be beneficial to use in engineering a trap.

Differentiation

Teachers can preselect teams based on student readiness or necessary accommodations.

Assessments

Teacher Observation
Cartoon Clip Activity (Appendix E)
Image Response Worksheet (Appendix D)

Section II: STEM Lesson Plan

Title of Lesson	**Day 3: Gravitational Force**
Time Required	50 minutes
Materials	Hands-on materials: golf ball, ping-pong ball, spring-triggered mouse-trap. Computer with INTERNET access. Student Handout (Appendix H) Teacher Notes (Appendix I)
Objectives	Students will explore gravitational force through a demonstration and small-group & teacher-led discussions. After the activity the students should understand that: 1. Gravitational force acts at a distance 2. Every object with mass experiences a gravitational force 3. Gravitational forces are proportional to the mass of the objects involved, and get weaker with distance. 4. The definitions of weight and mass. Weight is gravitational force and is often confused with mass which is a fundamental property of matter.
Instructional Process	1) Demonstration: (~10 minutes)Demonstrate a ping-pong and a golf ball falling to the ground. Teacher leads a discussion about gravitational force. Students complete a worksheet. 2) Video: (~25 minutes)Watch the ‘Mass vs. Weight: Introduction’ video at NASA’s educational website (http://education.ssc.nasa.gov/mvw_intro_video.asp) and complete the worksheet. Teacher goes over the worksheet and leads a discussion. The video can be downloaded before class and saved if INTERNET is unavailable. Students complete a worksheet and small-group discussion(http://education.ssc.nasa.gov/video/mvw/introduction_mvw.mp4) 3) Student activity: (~15 minutes)Instructor leads a discussion of the force of gravity in space. Students use gravitational force to activate a real mouse trap.
Differentiation	Modifications can be made to the student tasks. For students that may require additional prompting, scaffolding can be added.
Assessments	Appendix H (Gravitational Forces Student Handout) Gravitational Force Discussion

Section II: STEM Lesson Plan

Title of Lesson

Day 4: Electrical and Magnetic Forces (with review of circuits)

Time Required

50 minutes

Materials

Appendix J: Electrical Force and Circuits Stations

C Batteries
Battery Clip
Light bulb
Wire
Switch
Cotton towel
Plastic Produce Bag
Scissors
Balloon

Objectives

Demonstrate the principles of electrical forces acting at a distance.
Review basic circuit concepts to complete the circuit.
Students can identify and create a circuit both with and without a switch.
Students can create and identify charges in an electrical field.

Instructional Process

Students will complete the following activities using Appendix J.
Station 1: Circuit Concepts
Station 2: Electrical Force
The following video is to demonstrate what the students will be creating while completing the Electrical Force worksheet, it is not meant to be shown to students.
https://www.youtube.com/watch?v=UejjhomhpOw

Differentiation

Teacher can have students complete just the series circuit. To challenge students have them build the pressure plate (question 11) and utilize it in the series and parallel circuit portion.

Assessments

Electrical Force and Circuit Stations - Appendix J

Section II: STEM Lesson Plan

Title of Lesson

Day 5: Electromagnetic Force Stations

Time Required

50 minutes

Materials

Light Sensor
Batteries (1.5 volt and 9 volt)
Magnet Wire
Breadboard
Coated Wire (Prototyping wire)
Battery Connector
Switches (optional)
Incandescent lights (small)
Paper Clips
Calculator
Iron Filings
CD jewel case
Packing Tape
Iron Nails
Aluminum Nails
Permanent Magnet
Voltmeter
Ruler
String
Neodymium magnet (1/2" sphere)
1/2" PVC pipe 3 ft length
1/2" copper pipe 3 ft length
1/2" ball (wooden, marble, bouncy ball, etc)
Appendix K: Electromagnetic Stations

Objectives

Students will describe the different characteristics and uses of an electromagnet.

Instructional Process

Teacher Set-up:
Teacher needs to pre-make electromagnets for each station.
Station #1 is the only station that needs a light in the series.
Station #2 has three different electromagnetic coils and no light needed. (Site with directions to make electromagnet without a breadboard: http://sciencebob.com/experiments/electromagnet.php)
Station #3: Put iron filings in CD case to fill and tape shut with packing tape to avoid filings from leaving.

1. Intro/Demo:
Hold the pipes vertical and drop the spheres, one at a time through each pipe. Drop the magnet through the copper pipe last. Time how long it takes for each object to go through the pipe. The magnet will take longer going through the copper pipe due to the magnetic field. The magnet through the PVC and other object through both pipes should take the same amount of time. Students will record observations including time it takes for the objects to travel through the pipes.

2. Students will move through stations, about 10 minutes each.

Station 1: Strength of voltage (input) vs. light intensity (output)

1. Students will be given two different batteries (1.5volt and 9 volt) to attach the series to the electromagnet.
2. Students will test the volts output using voltmeter and then evaluate the relative (bright or dim) light output. (a light sensor can be used if available)

Station 2: # of times wire wrapped vs. distance of magnetic field
1. Teacher will provide an iron nail wrapped 10, 50, 100 times with the magnetic wire for the station. This can have the breadboard already created for all three or students can switch-out the nail/wire combination. The paper clip is suspended from the edge of the table using a string.
See picture of set-up in printable resources

2. Students will hold the electromagnetic away from the small paper clip to test the strength of the magnet. They will slowly move the paper clip closer to the electromagnet recording the distance when the magnet begins pulling on the paper clip.
3. Students will test will all three wrapped nails and graph the data and then create a line of best fit. (optional have students write linear-equation by calculating slope and x- and y-intercept)

Station 3: Drawing of field
1. Students will draw the magnetic field of the electromagnetic as represented by the iron filings contained in the CD jewel case.
2. Students will hold the electromagnetic parallel and perpendicular to the CD case drawing the field.
3. Students will repeat the process with a permanent magnet.
4. Students will complete the summary/wrap-up questions at the end. The questions require them to support their answers with evidence collected from the stations.

See Appendix L for additional resources for teachers

Differentiation

Students with higher math skills can use the equation from Station 2 to predict the number of coils needed to generate a magnetic field of a given size.
Students may have difficulty with the calculation of slope and intercepts, walk through the process as a team for assistance.
Teams can create their own electromagnets for additional hands-on practice.

Assessments

Students will be assessed on their Station document. Students will complete follow-up questions having to use the information they collected to describe the electromagnetic fields.

Section II: STEM Lesson Plan

Title of Lesson — **Day 6: Introduce Challenge, Research**

Time Required — 50 minutes

Materials

Student access to Internet
Cardboard
Coffee cans
Small soup cans
String
2 liter bottles
Bucket
Rubber bands
Tape
Paper towel rolls
Spoons
Paper plates
Coins
Magnets
Wind-up toys or marbles
Stopwatches
Data collection sheet
Appendix N: Engineering Design Challenge
Appendix O: Engineering Design Challenge Rubric
Appendix P: Bill of Materials

Objectives

Students will create detailed sketch of original trap. The design must be legible, labeled, and dimensioned in metric.
Students will create bill of materials (cost of raw materials to make the trap) for the original design by completing the Bill of Materials worksheet.

Instructional Process

1. Introduce the challenge to the students. Hand out the rubric and go through the requirements with the class.

2. Once the challenge is introduced, show the students the materials available to them and how much they cost. Remind students that as they use materials they need to keep track of their cost. (Teacher needs to decide on the cost restrictions.)

3. Go through an example on how to fill out the Bill of Materials worksheet with students.

4. Once students have all the information, ask them what they need to do next in order to have a successful trap
a. Probe students to say research
b. Explain how research is an important part of any engineering design

5. Monitor them as they complete this research Online.

6. For homework, have students complete a sketch of what they think the optimal trap will be.

Differentiation

For gifted students, have them find their own research.
For struggling students, lead them to one or two websites or show pictures of pre-made traps.

Assessments

Bill of Materials (Appendix P)
Rubric (Appendix O)
Individual Designs

Section II: STEM Lesson Plan

Title of Lesson

Day 7/8 -- Design and Build

Time Required

100 minutes

Materials

Cardboard
Coffee cans
Small soup cans
String
2 liter bottles
Bucket
Rubber bands
Tape
Paper towel rolls
Spoons
Paper plates
Coins
Magnets
Wind-up toys or marbles
Stopwatches
Data collection sheet (Appendix S)

Objectives

Students will create detailed sketch of original trap. The design must be legible, labeled, and dimensioned in metric.
Students will create bill of materials (cost of raw materials to make the trap) for the original design by completing the Bill of Materials worksheet.

Instructional Process

1. Students will be in their teams, designing and building their mousetraps.
2. Students will created sketches of their traps.
3. Students will create a bill of materials for their trap.

Differentiation

Teams need to have at least one force represented (gravitational). As a challenge, increase the number of forces that need to be present in their design.

Assessments

Engineering Design Challenge Rubric (Appendix O)

Section II: STEM Lesson Plan

Title of Lesson

Day 9 -- Testing and Redesign

Time Required

50 minutes

Materials

Cardboard
Coffee cans
Small soup cans
String
2 liter bottles
Bucket
Rubber bands
Tape
Paper towel rolls
Spoons
Paper plates
Coins
Magnets
Wind-up toys or marbles
Stopwatches
Data collection sheet
Appendix S: Testing: Data Collection Sheet
Appendix Q: Presentation Details

Objectives

Students will test their designs and redesign based on the rubric, or to make the design more cost-effective.

Instructional Process

1. Students will begin testing traps. Pass out Appendix R. Students will test their trap five times by using a mechanical toy, found at any store or by rolling a marble, if toys are unavailable, into the trap. Students should record data on their table. Students may need to practice with the toy or marble before timing their trap.
2. Students should calculate the mean time it took for the animal to be trapped.
3. Compete the follow-up questions on the handout. Appendix S
4. Complete a detailed sketch of their redesigned trap. Be sure to include any needed modifications.
5. Make any necessary modifications to their original trap.
6. Students will continue to work on their Bill of Materials.

Differentiation

Teachers can require teams to add additional forces to teams in need of enrichment.

Assessments

Informal observation of team collaboration and brainstorming during redesign.

Section II: STEM Lesson Plan

Title of Lesson — **Day 10 -- Presentations**

Time Required — 50 minutes

Materials

Presentation materials – Teacher's choice (poster board; computer (presentation software, e.g.., PowerPoint))
Appendix T: Design Scalability Worksheet

Objectives

For homework, students will complete design scalability worksheet.

Instructional Process

1. Students will continue redesign activity form Day 9. Activities include:
- Create detailed sketch of redesigned trap
- Update Bill of Materials for materials needed to make redesigned trap

2. Students will create presentation to share with entire class. The audience for the presentation is Billy the Exterminator's representative who is going to decide if Billy wants to select and buy your trap design. Type/formality of presentation is teacher's choice: informal presentation where students use traps, sketches, bill of materials as props; use poster board to storyboard the project like a science fair project; create formal presentation on computer. Reference Appendix O: Engineering Design Challenge Rubric and Appendix Q: Presentation Details. Each team member will create and present a different aspect of the entire project:
- Mechanical Engineer
o Explain how the redesigned trap works
o Why they chose specific design elements
o Explain how the forces were used in the design
- Project Manager
o Describe the original design
o Explain what they learned from their original design and how they used that information in the redesign
o Present final testing results for the redesign
- Materials Engineer
o Describe why they chose specific materials for the original and redesign and cost reduction
o Explain the Bill of Materials
- Biologist
o Describe the critical attributes of the animal
o Explain why the original and/or redesign trap is humane
- Each team member
o Explain if they could do one more redesign, what would they change?

3. Homework: Complete Appendix S: Design Scalability Worksheet. Each student will need to take a copy of the redesign sketch home with him or her to complete the Worksheet

Differentiation

Requirements for presentation can be adjusted to team needs (e.g.., type of presentation, depth of information and design analysis)

Appendix T: Design Scalability

Section II: STEM Lesson Plan

Title of Lesson — **Day 11: Presentations and Post-Test**

Time Required — 50 minutes

Materials

Appendix A: Pre/Post test
Appendix B: Pre/Post test key
Appendix O: Engineering Design Challenge Rubric

Objectives

Students will submit Day 10 homework; present to class; submit design sketches and bills of materials for original design trap and redesigned trap; take post-test.

Instructional Process

1. Students turn in homework (Design Scalability worksheet)

2. Students finish and practice presentation.

3. Each team presents their presentation to the class.

4. Students submit design sketches and bills of materials for original design trap and redesigned trap.

5. Students take the post-test.

Differentiation

Requirements for presentation, e.g.., type of presentation, depth of information and design analysis

Assessments

Presentations
Design sketches
Bill of materials
Design Scalability worksheet
Post-test

Section III: Unit Resources

Materials and Resource Master List

Projector with Internet access
Calculator
Computer with Internet Access
Golf ball
Ping-pong ball
Spring-triggered mouse-trap
C Batteries
Battery Clip
Light bulb
Wire
Switch
Cotton towel
Plastic Produce Bag
Scissors
Balloon
Light Sensor
Batteries (1.5 volt and 9 volt)
Magnet Wire
Breadboard
Coated Wire (Prototyping wire)
Battery Connector
Switches (optional)
Incandescent lights (small)
Paper Clips
Calculator
Iron Filings
CD jewel case
Packing Tape
Iron Nails
Aluminum Nails
Permanent Magnet
Voltmeter
Ruler
String
Neodymium magnet (1/2" sphere)
1/2" PVC pipe 3 ft length
1/2" copper pipe 3 ft length
1/2" ball (wooden, marble, bouncy ball, etc)

Engineering Design Challenge Specific Materials:
Student access to Internet
Cardboard
Coffee cans
Small soup cans
String
2 liter bottles
Bucket
Rubber bands
Tape
Paper towel rolls
Spoons
Paper plates
Coins
Magnets
Wind-up toys or marbles
Stopwatches

Key Vocabulary

Circuit: A closed path followed or capable of being followed by an electric current. (thefreedictionary.com)

Electrical Current: The rate of flow of electrical charge through a surface (such as a wire cross-section), measured in amps (A), the SI units. By convention, positive charge flowing from left to right indicates a positive current flowing to the right. This is synonymous with negative charge flowing from right to left. In practice, negative charge is more mobile than positive charge, so the direction of positive current flow is opposite to the direction of the moving (negative) charge. In practice, it is not important to label the current in any particular direction. The direction of current can be indicated by a positive or negative number. In fact, in AC (Alternating Current) circuits the current flow positive, then negative in a sinusoidal waveform at a frequency of 60 Hz.

Electrical Force: The force exerted by stationary objects bearing electric charge on other stationary objects bearing electric charge. Objects of the same charge attract and objects of opposite charge repel. (thefreedictionary.com)

Electromagnet: A magnet consisting essentially of a coil of insulated wire wrapped around a steel or iron core that is magnetized only when current flows through the wire. (thefreedictionary.com)

Field: A region of space characterized by a physical property, such as gravitational or electromagnetic force or fluid pressure, having a determinable value at every point in the region. (thefreedictionary.com)

Force : The effect through which the motion or position of an object is changed.

Gravitational Force :The attractive force that arises from gravitational interaction. Newton’s law of gravity states that the gravitational force between two bodies is proportional to the product of their masses and inversely proportional to the square of the distance between them. (thefreedictionary.com)

Magnetic force: Attraction or repulsion that arises between electrically charged particles because of their motion; the basic force responsible for the action of electric motors and the attraction of magnets for iron. (Britannica)

Non-contact Force:Two objects who do not have any physical contact.

Parallel Circuit: In an electrical circuit, elements in parallel share the same voltage difference.

Series Circuit: In an electrical circuit, elements in series share the same current.

Simple Circuit: An example of a simple circuit consists of three elements: a source or electricity (battery), a path or conductor on which electricity flows (wire), and an electrical resistor (lamp) which is any device that require electricity to operate.

Trigger: A device used to release or activate a mechanism.

Volt: Voltage is the unit of measure in SI.

Voltage: Difference in the electrical potential between two nodes.

Technical Brief

See Appendices I, L and R

Safety and Disposal

Students should wear safety goggles when needed. Students should demonstrate caution when working with sharp objects. Students should avoid trapping themselves while constructing and testing their traps.
Students should avoid using their bodies to complete the circuit to avoid sending electrical current through their body.
Materials should be recycled, when available, and disposed of in the appropriate location and method. Inspect batteries regularly, dispose of if there are any signs of leakage.

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1. The National Institute of Standards and Technology disseminates values of fundamental physical constants, related SI units, and related information on material properties (http://physics.nist.gov/cuu/index.html)

2. The American Psychological Association describes some common alternative science conceptions (misconceptions) held by junior and high school students (http://apa.org/education/k12/alternative-conceptions.aspx)

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Section IV: Appendices

A: Pre/Post Test
B: Pre/Post Test Answer Key
C: The Hook Student Worksheet
D: Image Response Worksheet
E: Cartoon Clips Station
F: Code of Cooperation
G: Career Roles
H: Gravitational Forces Student Handout
I: Gravitational Forces Teacher Resources
J: Electrical Force and Circuit Stations
K: Electromagnetic Stations
L: Teacher Guide to Forces with Demonstrations
M: Teacher Resource: Mouse Trap Designs
N: Engineering Design Challenge
O: Engineering Design Rubric
P: Bill of Materials
Q: Presentation Details
R: Brief Technical Discussion of Gravitational and Electromagnetic Forces
S: Testing – Data Collection Sheet
T: Design Scalability Worksheet