



VEX ***IQ*** Robotics Education Guide

Teacher Supplement



VEX IQ Robotics Education Guide Teacher Supplement

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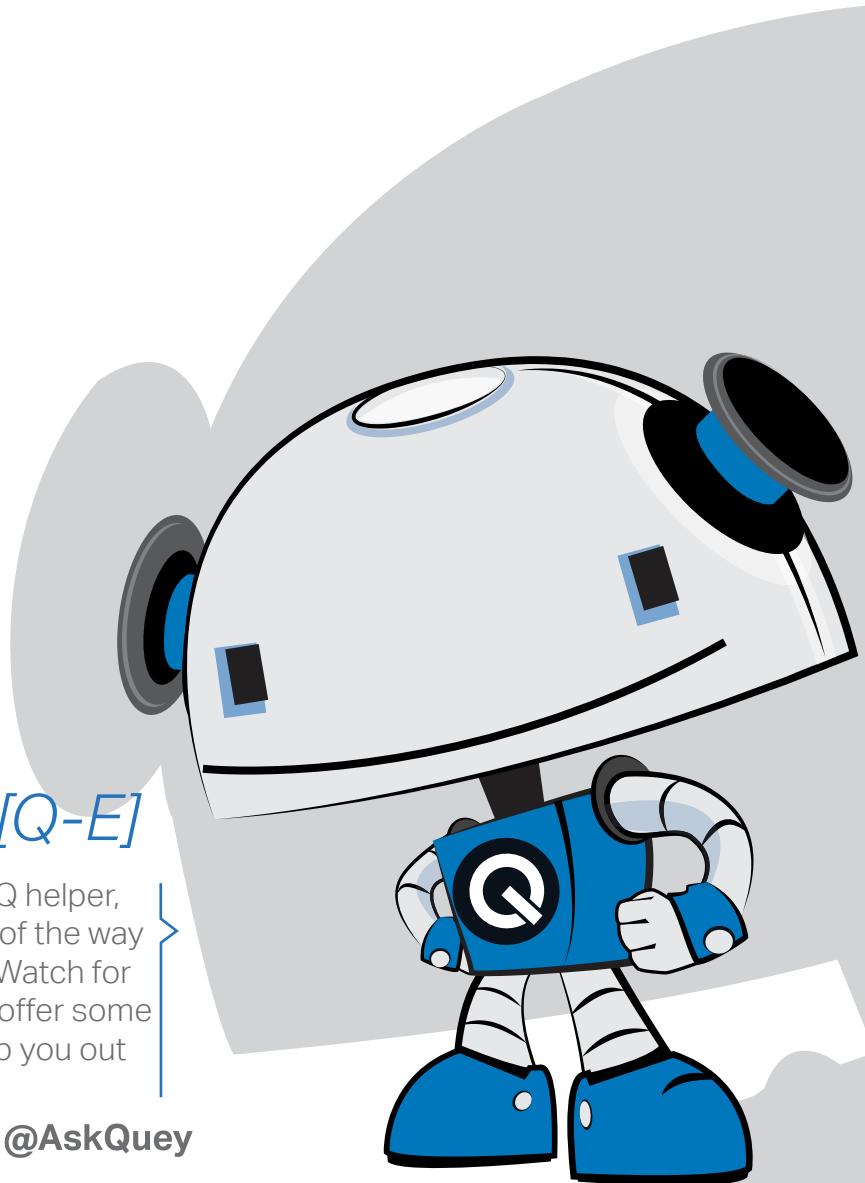
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I'm **Quey**, your personal VEX IQ helper, and I'll be with you every step of the way as you learn how to use VEX IQ! Watch for me on the sidelines - I'll try to offer some tips and tricks that should help you out when things get tough.



VEX IQ Robotics Education Guide Teacher Supplement Overview

To Our Teachers:

In our efforts to provide the tools you need to embark on this tremendous classroom and/or after-school experience, the VEX IQ Robotics Education Guide and this Teacher Supplement are meant to be used together as you map out this journey with your students. With that in mind, we present you with some versatile options to meet your needs. Although the curriculum material (both online and in these publications) is presented as sequential units, it can be used in very flexible ways depending on your desires and needs. Some of the materials are prescriptive lessons that follow specific instructions, while others are more open-ended challenges that can be taken on as time and comfort allow.

The VEX IQ Curriculum:

All of the VEX IQ Curriculum materials found in these publications are also accessible online at www.vexiq.com/curriculum. Fully mapped to the latest education standards, the curriculum leverages the power and excitement of hands-on learning through machines and robots. It utilizes the VEX IQ platform to create exciting, engaging, and accessible STEM-related lessons for elementary to middle school students. While much of the VEX IQ Curriculum targets students in grades 4-6 (age 9-12), there are many lessons that are accessible as early as grades 2 or 3 (age 7-9) and others that have applications up through grades 7 and 8 (age 12-14). Recommended grade levels are listed with each unit and lesson, where applicable.

The materials have been created to ensure that students with varying learning styles and levels can accomplish lesson goals. No prior STEM or robotics experience is required for students or teachers. The VEX IQ Curriculum is designed to help you teach STEM-related lessons to elementary and middle school students in a highly engaging hands-on manner. Whether you're leading a classroom or co-curricular club, preparing for a VEX IQ Challenge event, or even learning in the comfort of your own home, the VEX IQ Curriculum is sure to stimulate learning and encourage creative problem solving.

Using the VEX IQ Robotics Education Guide and this Teacher Supplement:

The VEX IQ Robotics Education Guide breaks down each of the 12 units on instruction into three basic parts: Unit Overview, Unit Content, and Unit Activities. All Rubrics, where applicable, are included with Unit Content. If you do not want your students to write on the activity pages in the Robotics Education Guide, then you can copy those pages ahead of time or print desired pages from the online version of the curriculum found at www.vexiq.com/curriculum.

After this Overview and a Syllabus, this Teacher Supplement is also organized by the 12 corresponding units of instruction to provide you with the additional information you'll need as an educator to make key instructional decisions. Included here for each unit you will find lesson plan information, classroom timing of lessons, helpful tips, education standards information for each activity, answer keys where applicable, and a notes page for your use. Since this publication is only intended to be a supplement, you'll find that only the most complex information from the Robotics Education Guide is repeated here.

Additional Resources at your Disposal:

In addition to your VEX IQ kit(s), the kit documentation, and these publications, you have a number of other helpful resources at your disposal. Teaching STEM with robotics kits can be very engaging and exciting; we want to be sure your efforts as a teacher are fully supported, enabling the most accessible pathway to learning for you and your students!

VEX IQ Website: <http://www.vexiq.com>

VEX IQ Curriculum Online: <http://www.vexiq.com/curriculum>

Download Build Instructions, Watch Videos, and More: <http://www.vexiq.com/explore>

VEX IQ Videos: <http://www.youtube.com/user/vexroboticstv> (choose VEX IQ under playlists)

VEX IQ Forum (share information, ask a question, or find answers): <http://www.vexiqforum.com>

VEX IQ Firmware Updater: <http://www.vexiq.com/firmware>

Programming Software Information: <http://www.vexiq.com/programming>

VEX IQ Curriculum Syllabus

Grade Level: 2-8 (units and lessons specify specific grade level targets)

Curriculum Duration: Flexible, depending on school and classroom needs.

50-80 hours of instruction if all 12 units are taught.

Curriculum Content Access: <http://www.vexiq.com/curriculum>

Curriculum Description & Options:

With the growing societal need to enhance science, technology, engineering, and mathematics (STEM) instruction in classrooms and beyond, there is a call for integrated learning programs that allow teachers to engage students meaningfully in STEM, especially at the elementary and middle school levels. With that in mind, we have developed the VEX IQ Curriculum as a companion to the VEX IQ platform for elementary and middle school students. This curriculum offers 12 flexible units of instruction that can be used in sequence, in chunks, or as standalone lessons. Whatever your elementary and middle school STEM education needs may be, the VEX IQ Curriculum is a learning tool that will excite and inspire your students. For information on the programming options available, consult www.vexiq.com/programming.

Curriculum Resources Provided:

Curriculum Lesson Content – 12 units and associated resources

Teacher Materials – lesson plans and assessment tools

Standards Matching – STL, NGSS, and Common Core

Resources – user guides, assembly instructions, helpful tips, classroom printables

Curriculum Materials (see individual units for more details):

Unit Webpages

Paper & Pencils

Colored Paper Cards

Protractor

VEX IQ Kits, Controller, & Sensors

Internet Access / Resources

Unit Printable Handouts & Assessments

Teacher Resources & Standards Matching

Idea Book Pages / Engineering Notebooks

Cubes or other Objects to Manipulate (see units for details)

VEX IQ Programming Software

VEX IQ User Guides & Kit Documentation

Curriculum Outline:

Unit A: It's Your Future – Learn about STEM, engineering, and robotics

Unit B: Let's Get Started – Learn about VEX IQ, the Controller, and the Robot Brain

Unit C: Your First Robot – Build and test Clawbot IQ

Unit D: Simple Machines & Motion – Explore Levers, Pulleys, Pendulums, & more

Unit E: Chain Reaction Challenge – Design fun devices using Simple Machines

Unit F: Key Concepts – Explore and apply science and math that engineers use

Unit G: Mechanisms – Motors, Gear Ratio, Drivetrains, Object Manipulation & more

Unit H: Highrise Challenge – Build a challenge-ready teleoperated robot

Unit I: Smart Machines – Learn how sensors work and the basics of programming

Unit J: Chain Reaction Programming Challenge – Apply sensor and programming knowledge to automate fun devices

Unit K: Smarter Machines – Expand your knowledge of sensors and programming

Unit L: Highrise Programming Challenge – Build a challenge-ready autonomous robot

Sample Curriculum Paths:

A Complete VEX IQ Course of Study (50-80 Hours):

All 12 Units of Instruction

Unpowered Excitement (10-15 Hours):

Units A, B, D, E

Learning Through The Competition Experience (19-24.5 Hours):

Units B, C, H, L

STEM Essentials for Competition Robotics (27-35 Hours):

Units B, C, F, G, H, I, L

Focus on Mechanical Design (15.5-18 Hours):

Units B, C, F, G, H

Focus on Programming & Autonomy (23-45.5 Hours):

Units B, I, J, K, L

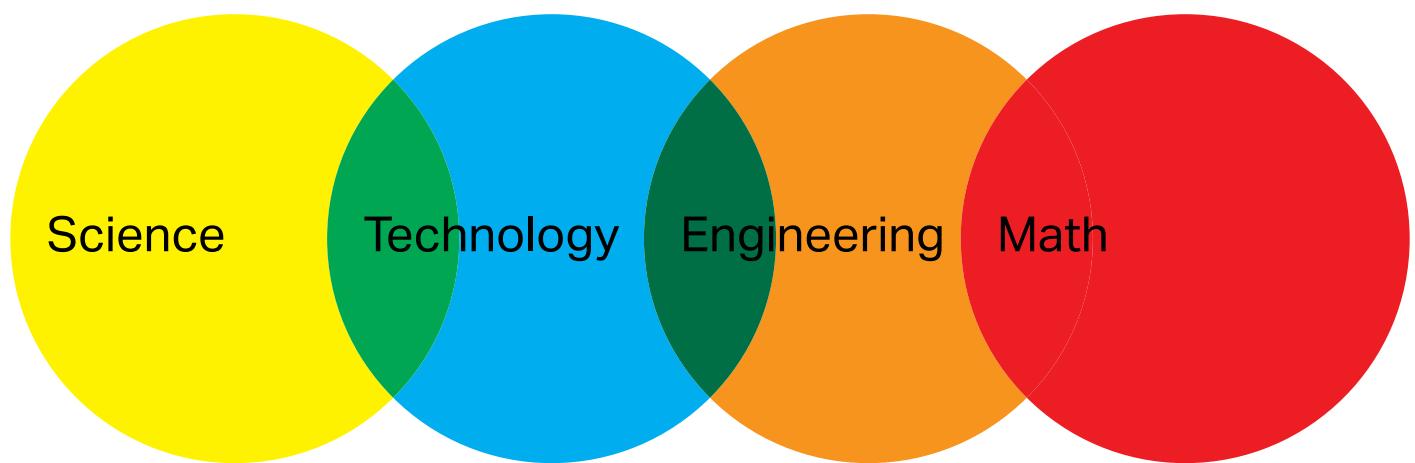
à la carte (time determined by teacher selection):

Pick and choose units & lessons to meet individual classroom needs.



It's Your Future

Teacher Unit Materials



A.t1

Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 2 to Grade 8

Suggested Prior Learning:

None

Unit Purpose:

The purpose of this unit is to introduce students to key concepts and terminology and show how their work with the VEX IQ platform relates to their future

Learning Objectives:

- Students will learn about the need for problem solvers in society
- Students will demonstrate that they know the meanings of STEM, engineering, and robotics
- Students will demonstrate that they know the meanings of the five basic types of engineering
- Students will demonstrate that they know the meanings of the three types of robot control

Unit Vocabulary:

STEM	Engineering
Chemical Engineering	Civil Engineering
Electrical Engineering	Mechanical Engineering
Specialized Engineering Fields	Robotics
Robot	Teleoperated Robots
Autonomous Robots	Hybrid Robots

Unit Materials:

-  Unit Content Material (A.1, A.2, A.3, A.4)
-  Unit Written Exercises (A.5, A.6)
- Unit Written Exercises Answer Key (A.t4)
- Pencils or pens
- Internet access or pre-printed research materials – optional
- Additional paper – optional

Unit Plan and Options:

5 Minutes:

Provide It's Your Future Unit Overview (A.1) and/or read from screen. Read It's Your Future "To Our Students" information together with students

15 Minutes:

Provide What is STEM, Engineering, and Robotics (A.2, A.3, A.4) and/or read from screen. Read and discuss STEM, Engineering, and Robotics information together with students.

20 Minutes:

Provide Matching Exercise (A.5). Students match unit terms with definitions in groups, alone, and/or for a quiz grade.

30+ Minutes (optional research activity):

Have students use the internet or pre-printed research information to collect and report information on teacher chosen topics from It's Your Future such as STEM, engineering types, or robot examples from society.

15+ Minutes (optional Idea Book activity):

Provide It's Your Future Idea Book Exercise (A.6). Following instructions on the Idea Book Exercise, have students imagine a robot that could solve a problem they know about. Then, draw a picture of what that robot might look like, give that robot a name, and write about what that robot would do.

A.t3

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
K-2	Engineering Design	K-2-ETS1-2	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.	- Optional Idea Book Exercise

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.B	K-2	Students will develop an understanding of the characteristics and scope of technology.	All people use tools and techniques to help them do things.	- Matching Exercise
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	- Matching Exercise - Optional Research Activity - Optional Idea Book Exercise
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	- Optional Research Activity - Optional Idea Book Exercise
3.A	K-2	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	The study of technology uses many of the same ideas and skills as other subjects.	- Matching Exercise
3.C	3-5	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	Various relationships exist between technology and other fields of study.	- Matching Exercise - Optional Research Activity - Optional Idea Book Exercise
3.F	6-8	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.	- Matching Exercise - Optional Research Activity - Optional Idea Book Exercise
6.A	K-2	Students will develop an understanding of the role of society in the development and use of technology.	Products are made to meet individual needs and wants.	- Optional Research Activity
6.B	3-5	Students will develop an understanding of the role of society in the development and use of technology.	Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.	- Optional Research Activity
6.D	6-8	Students will develop an understanding of the role of society in the development and use of technology.	Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.	- Optional Research Activity
9.A	K-2	Students will develop an understanding of engineering design.	The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.	- Optional Idea Book Exercise

A.t4 ANSWER KEY

It's Your Future Matching Exercise

Student Name(s): _____

Teacher/Class: _____ Date: _____

Instructions:

Match terms from the word bank to the correct definition by writing terms on the correct line. Each term is only used once.

Word Bank:

Autonomous Robots	Chemical Engineering	Civil Engineering
Electrical Engineering	Engineering	Hybrid Robots
Mechanical Engineering	Robot	Robotics
Specialized Engineering	STEM	Teleoperated Robots

STEM combines science, technology, engineering, and mathematics education to form an engaging field of study.

Engineering is using practical & scientific knowledge to create solutions for identified problems.

Chemical Engineering uses physical and biological sciences to convert raw materials or chemicals into more useful forms for the purpose of solving a problem.

Civil Engineering uses design, construction, and maintenance of physical and natural built environments to solve a problem.

Electrical Engineering uses electricity, electronics, and electromagnetism to solve a problem.

Mechanical Engineering uses design, construction, and mechanical power to create machines and mechanical systems that solve a problem.

Specialized Engineering fields use two or more types of engineering together to form a brand new kind of engineering.

Robotics is the specialized type of engineering that deals with the design, construction, operation, and application of robots.

A **Robot** is any man-made machine that can perform work or other actions normally performed by humans.

Robots operated by remote control are called **teleoperated robots**.

Robots operated automatically by themselves are called **autonomous robots**.

Robots that have both teleoperated and autonomous features are called **hybrid robots**.

A.t5

Unit Notes

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B

Let's Get Started

Teacher Unit Materials



B.t1

Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 2 to Grade 8

Suggested Prior Learning:

None

Unit Purpose:

The purpose of this unit is to introduce students to the VEX IQ platform hardware, Controller, Robot Brain, and to understand each item's function.

Learning Objectives:

- Students will be exposed to key resources that aid in working with the VEX IQ platform
- Students will learn hardware, Controller, and Robot Brain functions
- Students will pair their Controller with the Robot Brain
- Students will be able to recognize VEX IQ hardware parts and components visually

Unit Vocabulary (VEX IQ Hardware & Components):

Beams	Specialty Beams	Plates
Connector Pins	Standoffs	Standoff Connectors
Corner Connectors	Shaft	Shaft Bushing
Shaft Lock Plates	Rubber Shaft Collars	Twist Lock Shaft Collars
Washers & Spacers	Pulleys	Rubber Belts
Rubber Band Anchor	Gears	Wheel Hubs and Tires
Tank Tread & Intake Kit	Chain & Sprocket	Controller
Robot Brain	Radio	Smart Cables
Smart Motor		

Unit Materials:

- Unit Content Materials (B.1, B.2, B.3)
- Unit Written Exercises (B.5)
- Unit Application Exercises (B.4)
- Unit Written Exercises Answer Key (B.t4)
- Pencils or pens
- Controller (if you've purchased for use) and Robot Brain
- Appropriate additional VEX IQ Kit Hardware & Components – optional
- Additional teacher created materials – optional
- Protractors – optional
- Internet access – optional
- Additional paper – optional

B.t2**Unit Plan and Options:****20 Minutes:**

Provide Let's Get Started Using VEX IQ Hardware (B.2) and Using the VEX IQ Controller and Robot Brain (B.3) and/or read from website screen and you review Hardware and Components. Optionally, you can use the actual kit hardware and components instead of (or in addition to) the handouts.

20 Minutes:

Provide Matching Exercise (B.5). Students will match terms with appropriate images in groups, alone, and/or for a quiz grade.

15 Minutes:

Provide Let's Get Started handout(s) of user guides for Controller and Robot Brain for students and/or read from website screen. Read, discuss, and perform startup activity (Pairing the Controller with the Robot Brain) then familiarize students with the features of the Controller and Robot Brain.

15+ Minutes (optional mathematics activity):

Teach students how to use a protractor by properly identifying 30, 45, 60, and 90 degree specialty beams. Alternately, you could use the same specialty beams without the protractors to conduct an estimation activity.

B.t3**Unit Standards Connections:****Standards for Technological Literacy (STL)**

Code	Grade	Standard	Benchmark	Unit Activities
1.B	K-2	Students will develop an understanding of the characteristics and scope of technology.	All people use tools and techniques to help them do things.	<ul style="list-style-type: none"> - Using The Hardware Handout - Using the VEX IQ Controller and Robot Brain Handout - Matching Exercise
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	<ul style="list-style-type: none"> - Using The Hardware Handout - Using the VEX IQ Controller and Robot Brain Handout - Matching Exercise
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	<ul style="list-style-type: none"> - Using The Hardware Handout - Using the VEX IQ Controller and Robot Brain Handout - Matching Exercise

Common Core Standards for Mathematics (CCSM)

Domain #	Grade	Cluster	Standard	Unit Activities
4.MD	4	Measurement & Data	Geometric measurement: understand concepts of angle and measure angles.	<ul style="list-style-type: none"> - Optional mathematics activity

B.t4 ANSWER KEY

Let's Get Started Matching Exercise

Student Name(s): _____

Teacher/Class: _____ Date: _____

Instructions:

Match terms from the word bank and label correctly below each picture (pictures are NOT to scale).

Word Bank:

Specialty Beam	Beam	Connector Pin	Controller
Corner Connector	Gear	Plate	Pulley
Radio	Robot Brain	Rubber Band Anchor	Rubber Belt
Rubber Shaft Collar	Shaft	Shaft Bushing	Smart Motor
Standoff	Standoff Connector	Tire	Wheel Hub



B.t5

Unit Notes

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B.t5 cont.

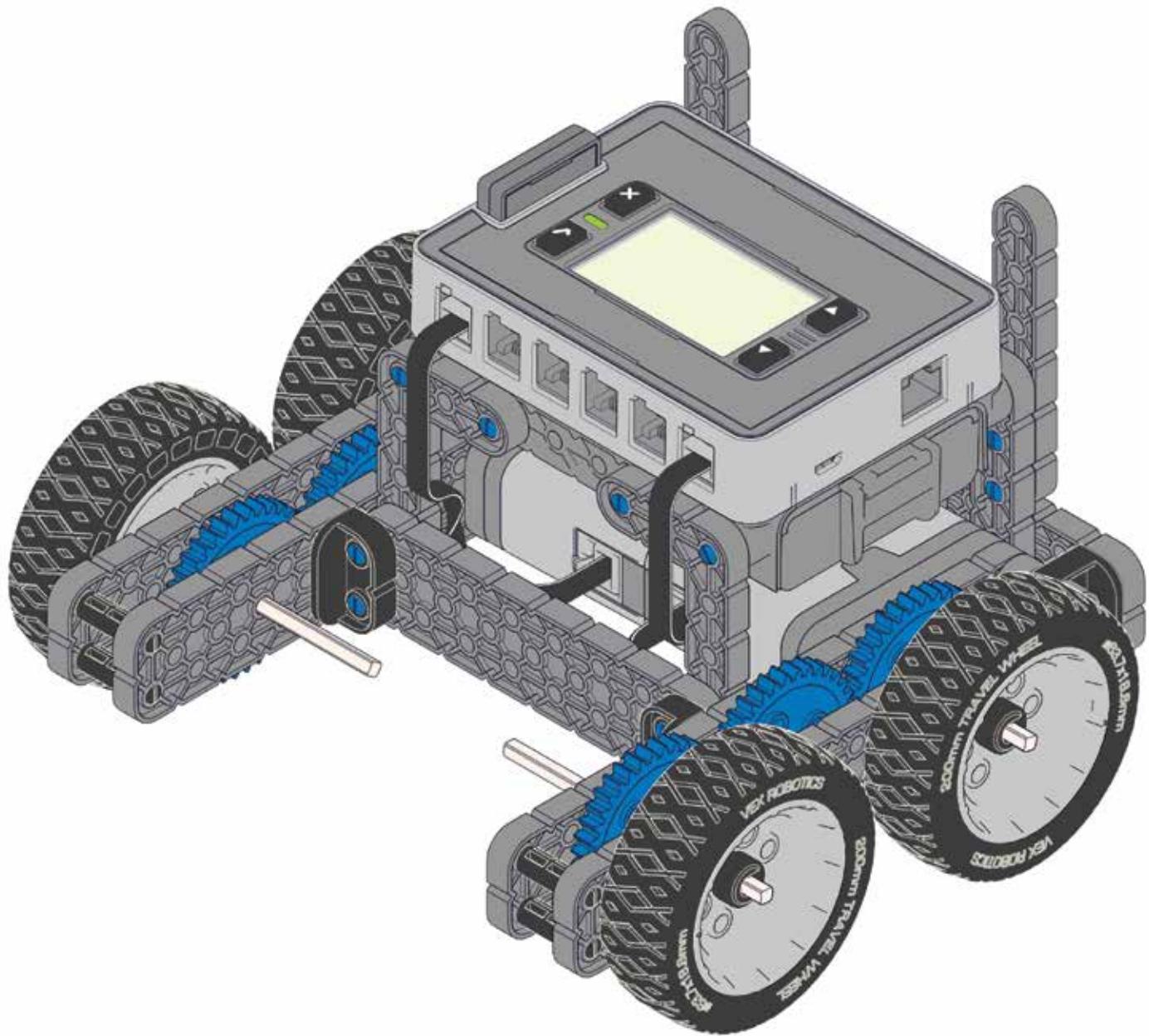
Unit Notes

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Your First Robot

Teacher Unit Materials



C.t1

Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 4 to Grade 8

Suggested Prior Learning:

- Lessons in Let's Get Started Unit or equivalent experiences

Unit Purpose:

The purpose of this unit is to introduce students to a completely documented robot build, following the Clawbot IQ step-by-step instructions.

Learning Objectives:

- Students will be able to follow instructions to build a functional VEX IQ robot
- Students will learn about and utilize the design process
- Students will be able to troubleshoot and solve problems to improve design

Unit Vocabulary

Design Process

Unit Materials:

- Unit Content Materials (C.1, C.2, C.4)
- Unit Rubric (C.5)
- Unit Written Exercises (C.6)
- Unit Build Instructions (C.3)
- Pencils or pens
- VEX IQ Robot Brain, Controller, and hardware as per Clawbot IQ Assembly Instructions
- Objects needed for robot testing (VEX IQ Challenge game objects, cubes, tennis balls, or similar)
- Internet access for website use – optional
- Additional paper – optional

C.t2

Unit Plan and Options:

20 Minutes:

Provide Your First Robot Unit Content Materials (C.1, C.2, C.4) for students and read, discuss, review the plans for the unit with students with special emphasis on design process and the "think-do-test loop".

30 Min – 2 Hours:

Provide Your First Robot Clawbot IQ Assembly Instructions (C.3), Build Rubric (C.5), and desired Idea Book Pages (C.6) to lead student through a documented build (using Idea Book Pages) of robot base, claw, tower, and/or ball holder. Time will vary depending upon how many parts of the Clawbot IQ you decide to have students build, document, and test. Optionally these parts of the build could be completed sequentially over several lessons and days if desired.

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
3-5	Engineering Design	3-5- ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	- Clawbot IQ Build - Idea Book Pages
3-5	Engineering Design	3-5- ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	- Clawbot IQ Build - Idea Book Pages

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	- Clawbot IQ Build - Idea Book Pages
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	- Clawbot IQ Build - Idea Book Pages
2.G	3-5	Students will develop an understanding of the core concepts of technology.	When parts of a system are missing, it may not work as planned.	- Clawbot IQ Build - Idea Book Pages
2.L	3-5	Students will develop an understanding of the core concepts of technology.	Requirements are the limits to designing or making a product or system.	- Clawbot IQ Build: Following Assembly Instructions
2.Q	6-8	Students will develop an understanding of the core concepts of technology.	Malfunctions of any part of a system may affect the function and quality of the system.	- Clawbot IQ Build - Idea Book Pages
2.R	6-8	Students will develop an understanding of the core concepts of technology.	Requirements are the parameters placed on the development of a product or system.	- Clawbot IQ Build: Following Assembly Instructions - Build Rubric
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	- Review of Content Materials - Idea Book Pages
8.G	6-8	Students will develop an understanding of the attributes of design.	Requirements for a design are made up of criteria and constraints.	- Clawbot IQ Build: Following Assembly Instructions
9.C	3-5	Students will develop an understanding of engineering design.	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.	- Clawbot IQ Build - Idea Book Pages

C.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
9.F	6-8	Students will develop an understanding of engineering design.	Design involves a set of steps, which can be performed in different sequences and repeated as needed.	- Review of Content Materials - Clawbot IQ Build - Idea Book Pages
10.C	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a way of finding out why something does not work so that it can be fixed.	- Clawbot IQ Build - Build Rubric - Idea Book Pages
10.E	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	The process of experimentation, which is common in science, can also be used to solve technological problems.	- Review of Content Materials
10.F	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.	- Clawbot IQ Build - Idea Book Pages
11.H	6-8	Students will develop abilities to apply the design process.	Apply a design process to solve problems in and beyond the laboratory-classroom.	- Clawbot IQ Build - Idea Book Pages
11.K	6-8	Students will develop abilities to apply the design process.	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	- Clawbot IQ Build: Following Assembly Instructions - Build Rubric - Idea Book Pages

C.t4

Unit Notes

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C.t4 cont.

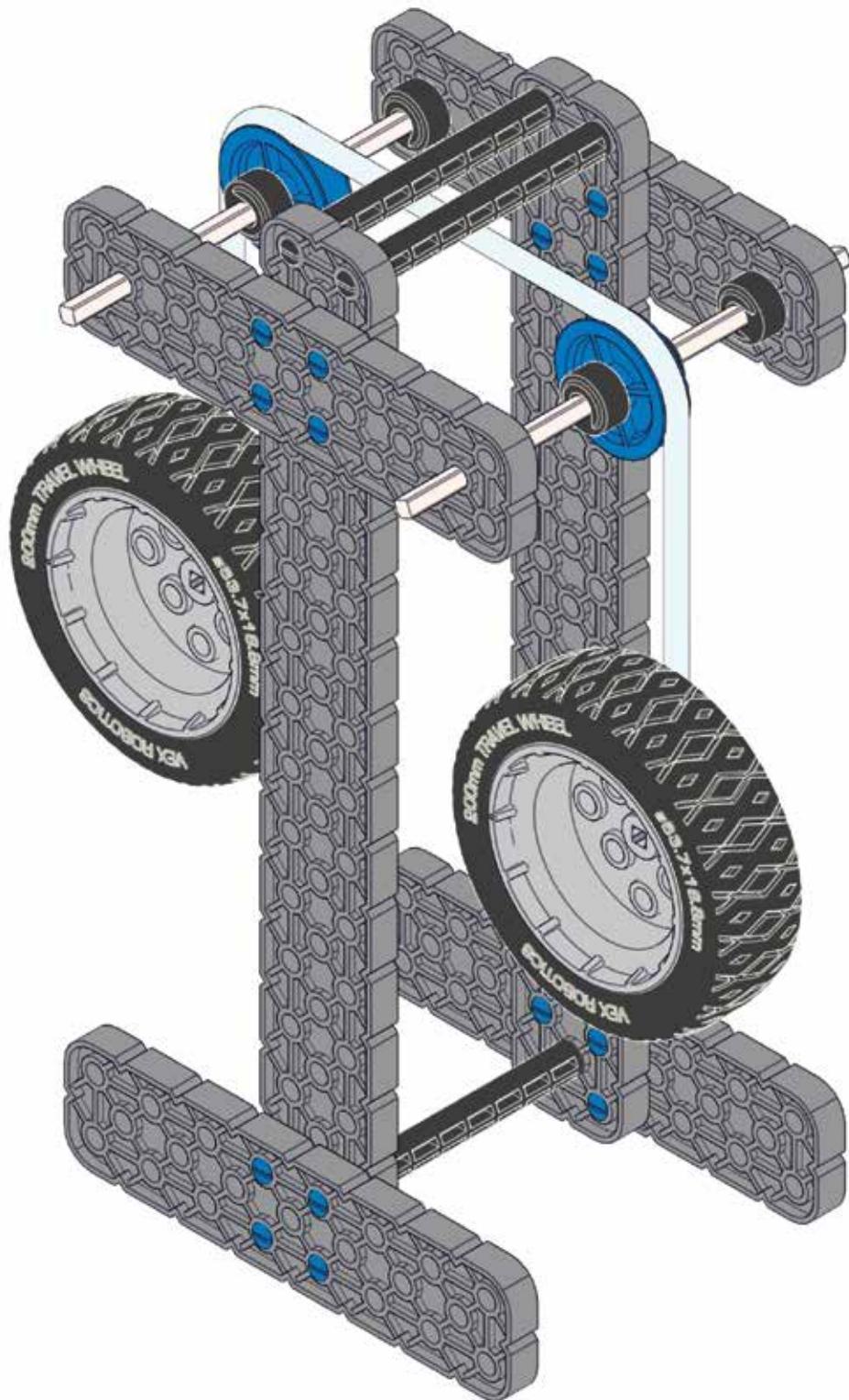
Unit Notes

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Simple Machines & Motion

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 2 to Grade 8

Suggested Prior Learning:

- Completion of the **Let's Get Started** unit is suggested
- Additionally, completion of the **Your First Robot** unit would be helpful for those completing the optional Simple Machines & Motion Robot Design activity in this unit

Unit Purpose:

The purpose of this unit is to introduce students to simple machines, pendulums, and corresponding terminology, then have them apply that knowledge through build and design activities.

Learning Objectives:

- Students will learn how simple machines make work easier
- Students will learn key terminology related to motion and the use of simple machines
- Students will be able to identify the six types of simple machines visually
- Students will document design
- Students will apply knowledge through grade-appropriate build and design activities

Unit Vocabulary:

Force	Friction	Fulcrum
Gravity	Inclined Plane	Lever Pendulum
Pulley	Screw	Simple Harmonic Motion
Simple Machine	Wedge	Wheel & Axle
Work		

Unit Materials:

- Unit Content Material (D.1, D.2, D.3)
- Unit Written Exercises (D.4, D.6, D.7)
- Unit Build Instructions (D.5)
- Unit Written Exercises Answer Key (D.t4)
- Pencils or pens
- VEX IQ Kit Hardware & Components (as needed for chosen lessons)
- String (for pulley assembly)
- Controller and Robot Brain (as needed for chosen lessons)
- Internet access – optional
- Additional paper – optional

Unit Plan and Options

30 Minutes:

Provide Simple Machines & Motion Unit Content Materials (D.1, D.2, D.3) for students and/or read from website screen to review and discuss information. Optionally, you can use the actual kit hardware and components instead of (or in addition to) the Robotics Education Guide wherever appropriate to show examples.

20-30 Minutes:

Provide student Matching Exercise (D.5). Students will match terms with appropriate definitions and/or images in groups, alone, and/or for a quiz grade. (Part I for grades 4-8; Part II for grades 2-6).

30+ Minutes

Provide VEX IQ Simple Machines & Motion Sample Assemblies Instructions (D.6) and have students build one or more of the assemblies (inclined plane, lever, pulley, pendulum). Discuss how each simple machine works and what practical use each has, tying back to descriptions and definitions from the Unit Content Materials (D.1, D.2, D.3).

30 Min – 2 Hours (optional activities):

Machine Design for Grades 2-6: Have students build their own models creatively for the remaining three simple machines (wedge, wheel and axle, and/or screw) and/or "new" models of inclined plane, lever, pulley, and/or pendulum. The corresponding Simple Machines & Motion Idea Book Exercise: (D.7) can be used to document these designs.

Robot Design For Grades 4-8: Starting with the Clawbot IQ Robot Base, add one simple machine or pendulum so the result is a teleoperated robot that moves a tennis ball, cube, or similar round object from a floor or table top onto a 25mm to 50mm (1-inch to 2-inch) high platform (a book will suffice for this exercise). You may assign which simple machine/pendulum students are to build or have the students pick. The corresponding Simple Machines & Motion Idea Book Exercise (D.7) can be used to document these designs.



Note: The most likely way for students to build models using a screw would be for them to use the worm gear sold separately from Starter or Super Kits as part of the Gear Kit P/N 228-2532. All other simple machines and the pendulum can be built from a Starter or Super Kit.

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
K-2	Engineering Design	K-2-ETS1-2	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.	<ul style="list-style-type: none"> - Sample Assembly Build(s) - Machine Design Activities - Robot Design Activities - Idea Book Exercises
3	Motion and Stability: Forces & Interactions	3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.	<ul style="list-style-type: none"> - Pendulum definition and Sample Assembly Build
5	Motion and Stability: Forces & Interactions	5-PS2-1	Support an argument that the gravitational force exerted by Earth on objects is directed down.	<ul style="list-style-type: none"> - Pendulum and gravity definition and Sample Assembly Pendulum Build
3-5	Engineering Design	3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	<ul style="list-style-type: none"> - Sample Assembly Build(s) - Machine Design Activities - Robot Design Activities - Idea Book Exercises
3-5	Engineering Design	3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	<ul style="list-style-type: none"> - Sample Assembly Build(s) - Machine Design Activities - Robot Design Activities - Idea Book Exercises
6-8	Energy	MS-PS3-5	Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.	<ul style="list-style-type: none"> - Use of pertinent definitions from content materials along with: - Robot Design Activities - Idea Book Exercises
6-8	Engineering Design	MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	<ul style="list-style-type: none"> - Machine Design Activities - Robot Design Activities - Idea Book Exercises
6-8	Engineering Design	MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	<ul style="list-style-type: none"> - Machine Design Activities - Robot Design Activities - Idea Book Exercises

D.t3 cont.

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	<ul style="list-style-type: none"> - Unit Content Materials Review - Sample Assembly Build(s) - Machine Design Activities - Robot Design Activities
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	<ul style="list-style-type: none"> - Machine Design Activities - Robot Design Activities - Idea Book Exercises
1.G	6-8	Students will develop an understanding of the characteristics and scope of technology.	The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.	<ul style="list-style-type: none"> - Machine Design Activities - Robot Design Activities - Idea Book Exercises
2.C	K-2	Students will develop an understanding of the core concepts of technology.	Tools are simple objects that help humans complete tasks.	<ul style="list-style-type: none"> - Unit Content Materials Review - Sample Assembly Build(s)
2.K	3-5	Students will develop an understanding of the core concepts of technology.	Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.	<ul style="list-style-type: none"> - Sample Assembly Build(s) - Machine Design Activities - Robot Design Activities - Idea Book Exercises
2.L	3-5	Students will develop an understanding of the core concepts of technology.	Requirements are the limits to designing or making a product or system.	<ul style="list-style-type: none"> - Following directions for Sample Assembly build(s) and Design Activities
3.F	6-8	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.	<ul style="list-style-type: none"> - Applying scientific definitions from unit Content Materials to: - Machine Design Activities - Robot Design Activities - Idea Book Exercises
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	<ul style="list-style-type: none"> - Idea Book Exercises in conjunction with Design Activities
8.G	6-8	Students will develop an understanding of the attributes of design.	Requirements for a design are made up of criteria and constraints.	<ul style="list-style-type: none"> - Following directions for Sample Assembly build(s) and Design Activities
10.E	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	The process of experimentation, which is common in science, can also be used to solve technological problems.	<ul style="list-style-type: none"> - Machine Design Activities - Robot Design Activities - Idea Book Exercises
11.H	6-8	Students will develop abilities to apply the design process.	Apply a design process to solve problems in and beyond the laboratory-classroom.	<ul style="list-style-type: none"> - Machine Design Activities - Robot Design Activities - Idea Book Exercises

D.t4 ANSWER KEY

Simple Machines & Motion Matching Exercise

Student Name(s): _____

Teacher/Class: _____ Date: _____

Part I Instructions:

Match terms from the word bank to the correct definition by writing terms on the correct line. Each term is only used once.

Part I Word Bank:

Force Friction Gravity Pendulum

Simple Harmonic Motion Simple Machines

Simple Machines are tools used to make work easier.

Work is a force acting on an object to move it across a distance.

A **force** is any push or pull that causes an object to change its position, direction, or shape.

Simple harmonic motion is what happens when an object is in motion in a non-complex periodic way.

A pendulum is a body suspended from a fixed point so that it can swing back and forth under the influence of gravity.

Gravity is the attraction between two masses, such as the earth and an object on its surface.

Friction is the force that resists motion through the rubbing of one object against another.

Part II Instructions:

Match terms from the word bank and label correctly below each picture.

Part II Word Bank:

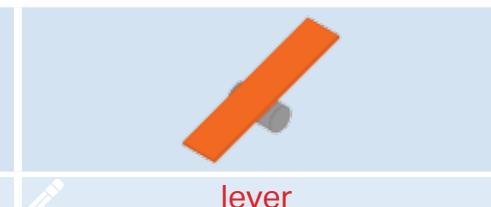
Inclined Plane Lever Pulley Screw Wedge Wheel & Axle



wheel & axle



screw



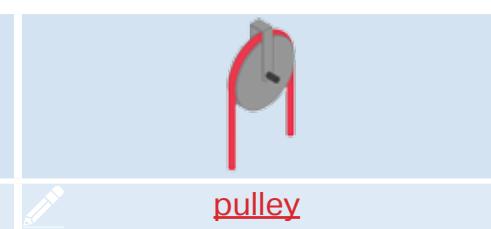
lever



wedge



inclined plane



pulley

D.t5

Unit Notes

A large rectangular area filled with a uniform grid of small, light-gray dots, designed for handwriting practice or note-taking. The grid consists of approximately 20 columns and 30 rows of dots, providing a structured surface for writing. The entire grid is enclosed within a thin blue border.

D.t5 cont.

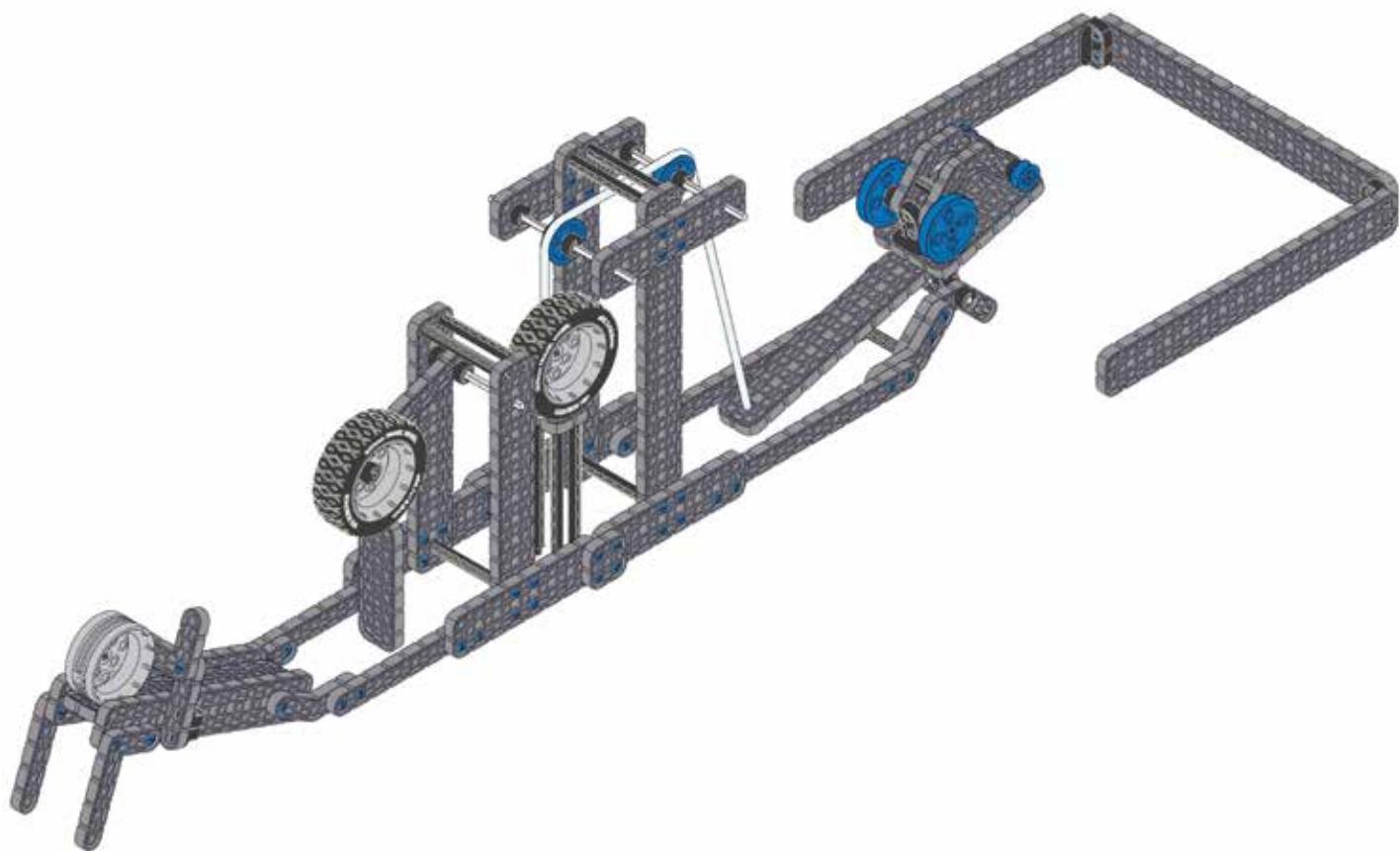
Unit Notes

A large rectangular area with a thin blue border, containing a grid of light gray dotted lines. The grid consists of approximately 20 horizontal rows and 20 vertical columns, creating a pattern of small squares for writing notes.



Chain Reaction Challenge

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 2 to Grade 8

Suggested Prior Learning:

- Completion of the Let's Get Started & Simple Machines & Motion units are suggested

Unit Purpose:

The purpose of this unit is for students to design and build a Chain Reaction Device to rubric specifications (either unpowered, powered, or both).

Learning Objectives:

- Students will apply knowledge of Simple Machines and Pendulums
- Students will learn key terminology related to Chain Reaction Devices
- Students will follow assembly instructions to build a sample Chain Reaction Device
- Students will utilize design process in building their own Chain Reaction Device(s)
- Students will document design
- Students will be able to troubleshoot and solve problems to improve design

Additional Purpose(s)/Objectives:

If desired, teachers can add additional content-specific purposes and objectives to any open-ended robotics challenge (like this unit provides) to develop corresponding targeted lessons around specific science, technology, and math content.

Unit Vocabulary:

- Chain Reaction Device
- Chain Reaction Stage
- Trigger Mechanism

Unit Materials:

- Unit Content Materials (E.1, E.2, E.4)
- Unit Rubrics (E.5, E.6)
- Unit Written Exercise (E.7)
- Unit Build Instructions (E.3)
- Pencils or pens
- VEX IQ Kit Hardware & Components (as needed for chosen lessons)
- String (for pulley assembly)
- Controller and Robot Brain (as needed for chosen lesson)
- Internet access - optional
- Additional paper - optional

Unit Plan and Options

20 Minutes:

Review information, terminology, and definitions related to Chain Reaction Devices from Unit Content Material (E.1, E.2, E.4).

45+ Minutes (optional, for grades 2-8):

Have students use the Sample Chain Reaction Device Assembly Instructions (E.3) to assemble and test a Four-Stage, Unpowered Chain Reaction Device that parks a car. Time needed for this activity will be longer if students have not assembled (or are not using) the **Simple Machines & Motion** Sample Assemblies built from the corresponding previous unit. Students in grades 2-3 can complete this activity INSTEAD of tackling the full challenge. Students in grades 4-8 should complete this activity only if you want students to see and test a Chain Reaction Device that "works" before taking on the open-ended challenge of "Parking the Car."

15 Minutes:

Review the **Chain Reaction Challenge** Rules (E.4) with student teams. The challenge is designed to use the car and garage models from the Sample Chain Reaction Device Assembly Instructions (E.3). You may choose to use a different car and/or garage design, or even have students build these creatively if desired and time allows. Choose the set of rules (Unpowered Device for grades 4-6 (E.5) or Powered Device for grades 4-8 (E.6)) that best fits your classroom needs. There is also the option of having students tackle both the unpowered AND powered versions of the challenge.

1 Hour:

Challenge planning using Idea Book Pages 1 and 2 from this unit. Have students plan and design a Chain Reaction Device that meets challenge and rubric criteria.

3+ Hours:

Student teams design, build, and test Chain Reaction Devices for the given challenge all while using the "THINK-DO-TEST" approach to completing troubleshooting Idea Book pages. Use the corresponding Rubric as a vehicle for improvement during the process and/or to assess final designs.

30+ Minutes:

Have students demonstrate their final/functional Chain Reaction Devices for whole class.

- Celebrate effort and results
- Optionally, create & give awards in addition to providing rubric and Idea Book Page feedback.

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
4	Energy	4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.	- Device Build(s) - Idea Book Pages
4	Energy	4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	- Device Build(s) - Idea Book Pages
3-5	Engineering Design	3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	- Device Build(s) - Idea Book Pages - Following Challenge Rules
3-5	Engineering Design	3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	- Device Build(s) - Idea Book Pages - Following Challenge Rules
3-5	Engineering Design	3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	- Device Build(s) - Idea Book Pages - Following Challenge Rules
6-8	Energy	MS-PS3-5	Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.	- Device Build(s) - Idea Book Pages
6-8	Engineering Design	MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	- Device Build(s) - Idea Book Pages
6-8	Engineering Design	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.	- Device Build(s) - Idea Book Pages
6-8	Engineering Design	MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	- Device Build(s) - Idea Book Pages

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	- Device Build(s) - Idea Book Pages
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	- Device Build(s) - Idea Book Pages

E.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
1.G	6-8	Students will develop an understanding of the characteristics and scope of technology.	The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.	- Device Build(s) - Idea Book Pages
2.G	3-5	Students will develop an understanding of the core concepts of technology.	When parts of a system are missing, it may not work as planned.	- Device Build(s) - Idea Book Pages
2.L	3-5	Students will develop an understanding of the core concepts of technology.	Requirements are the limits to designing or making a product or system.	- Device Build(s) - Idea Book Pages
2.Q	6-8	Students will develop an understanding of the core concepts of technology.	Malfunctions of any part of a system may affect the function and quality of the system.	- Device Build(s) - Idea Book Pages
2.R	6-8	Students will develop an understanding of the core concepts of technology.	Requirements are the parameters placed on the development of a product or system.	- Following Challenge Rules
2.U	6-8	Students will develop an understanding of the core concepts of technology.	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.	- Device Build(s) - Idea Book Pages
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	- Device Build(s) - Idea Book Pages
8.D	3-5	Students will develop an understanding of the attributes of design.	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.	- Following Challenge Rules
8.F	6-8	Students will develop an understanding of the attributes of design.	There is no perfect design.	- Device Build(s) - Idea Book Pages - Following Challenge Rules
8.G	6-8	Students will develop an understanding of the attributes of design.	Requirements for a design are made up of criteria and constraints.	- Following Challenge Rules
9.C	3-5	Students will develop an understanding of engineering design.	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.	- Device Build(s) - Idea Book Pages - Following Challenge Rules

E.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
9.D	3-5	Students will develop an understanding of engineering design.	When designing an object, it is important to be creative and consider all ideas.	- Device Build(s) - Idea Book Pages
9.F	6-8	Students will develop an understanding of engineering design.	Design involves a set of steps, which can be performed in different sequences and repeated as needed.	- Device Build(s) - Idea Book Pages
9.G	6-8	Students will develop an understanding of engineering design.	Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.	- Device Build(s) - Idea Book Pages
10.C	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a way of finding out why something does not work so that it can be fixed.	- Device Build(s) - Idea Book Pages
10.D	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	The process of experimentation, which is common in science, can also be used to solve technological problems.	- Device Build(s) - Idea Book Pages
10.E	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	The process of experimentation, which is common in science, can also be used to solve technological problems.	- Device Build(s) - Idea Book Pages
10.F	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.	- Device Build(s) - Idea Book Pages
10.G	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.	- Device Build(s) - Idea Book Pages

E.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
10.H	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Some technological problems are best solved through experimentation.	- Device Build(s) - Idea Book Pages
11.F	3-5	Students will develop abilities to apply the design process.	Test and evaluate the solutions for the design problem.	- Device Build(s) - Idea Book Pages
11.G	3-5	Students will develop abilities to apply the design process.	Improve the design solutions.	- Device Build(s) - Idea Book Pages
11.H	6-8	Students will develop abilities to apply the design process.	Apply a design process to solve problems in and beyond the laboratory-classroom.	- Device Build(s) - Idea Book Pages
11.K	6-8	Students will develop abilities to apply the design process.	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	- Device Build(s) - Idea Book Pages

Common Core Standards for Mathematics (CCSM)

Domain #	Grade	Cluster	Standard	Unit Activities
4.OA	4	Operations and Algebraic Thinking	Use the four operations with whole numbers to solve problems.	- Idea Book Pages
4.MD	4	Measurement and Data	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	- Idea Book Pages
4.MD	4	Measurement and Data	Represent and interpret data.	- Idea Book Pages
6.EE	6	Expressions and Equations	Represent and analyze quantitative relationships between dependent and independent variables.	- Idea Book Pages
7.RP	7	Ratios and Proportional Relationships	Analyze proportional relationships and use them to solve real-world and mathematical problems.	- Idea Book Pages



NOTES: Given the nature of an open-ended challenge like the one in this unit of study, it's not feasible to list all possible standards connections. The standards listed above are only samples and a fraction of what can be accomplished with this unit. We encourage educators to delve deeper into the areas of STEM most meaningful and useful to their students, tailoring Idea Book entries and/or adding their own lessons where they'd like.

Areas to find/develop additional standards connections for this unit:

NGSS: Structure and Properties of Matter, Energy, Engineering Design, Forces and Interactions

STL: The Nature of Technology, Design, Abilities for a Technological World, The Designed World

CCSM: Operations and Algebraic Thinking, Number and Operations – Fractions, Measurement and Data, Geometry, Ratios and Proportional Relationships, Expressions and Equations, Statistics and Probability.

E.t4

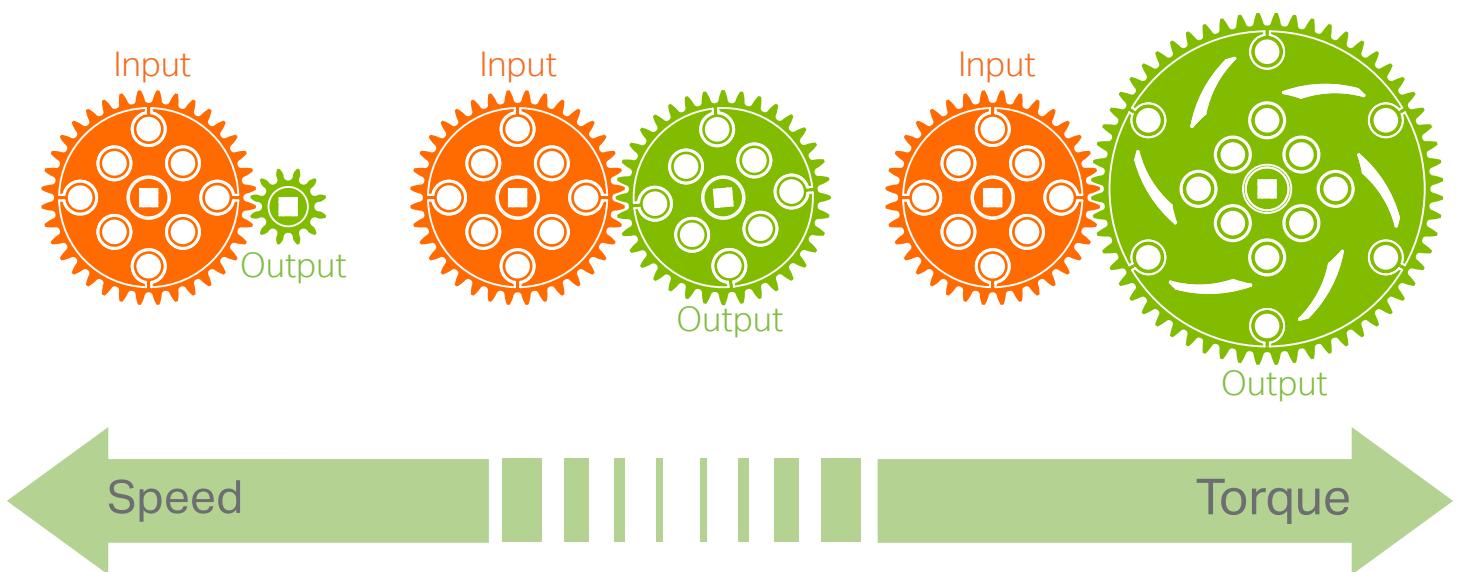
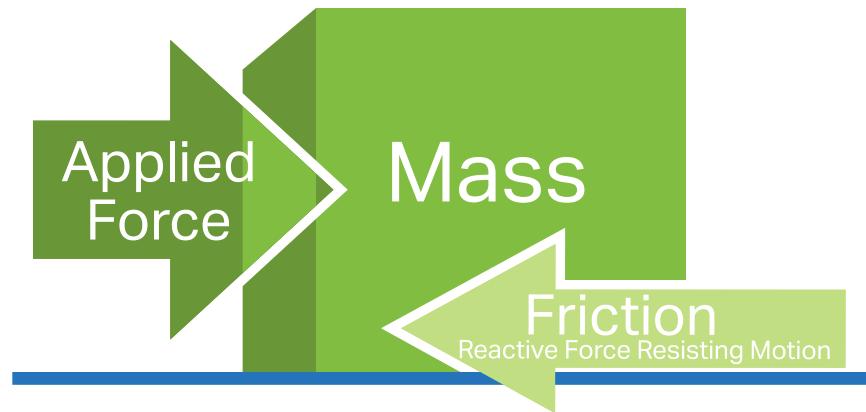
Unit Notes

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F

Key Concepts

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 2 to Grade 8

Suggested Prior Learning:

- Completion of the Let's Get Started, Simple Machines & Motion, and Your First Robot units are suggested

Unit Purpose:

The purpose of this unit is for students to learn about and apply knowledge of key concepts related to mechanical design.

Learning Objectives:

- Students will learn about and apply knowledge of Friction
- Students will learn about and apply knowledge of Center of Gravity
- Students will learn about and apply knowledge of Classical Mechanics
- Students will learn about and apply knowledge of Mechanical Advantage
- Students will learn key terminology related to mechanical design

Additional Purpose(s)/Objectives:

If desired, teachers can add additional content-specific purposes and objectives to any open-ended robotics challenge (like this unit provides) to develop corresponding targeted lessons around specific science, technology, math, and computer science content.

Unit Vocabulary:

- Center of Gravity Friction
- Inverse
- Mechanical Advantage Power
- Speed Torque

Unit Materials:

- Unit Content Material (F.1, F.2, F.3, F.4, F.5)
- Unit Written Exercises (F.6, F.7)
- Unit Written Exercise Answer Key (F.t4)
- Pencils or pens
- Lever Assembly from Simple Machines & Motion Unit
- Clawbot IQ
- Cube, Tennis Ball, or similar object(s)
- Internet access for website use – optional
- Additional paper – optional

Unit Plan and Options

30 Minutes (for grades 2-8):

Provide students with Unit Content Materials (F.1, F.2, F.3, F.4, F.5). Review information, terminology, and definitions related to Key Concepts with them.

30 Minutes (for grades 2-8):

Provide students with Matching Exercise (F.6) for the unit. Students match terms with appropriate definitions and phrases in groups, alone, and/or for a quiz grade.

15 Minutes (for grades 2-6):

Have students use the lever assembly from the Simple Machines & Motion unit to balance the "seesaw" and show approximately where the center of gravity must be. You can have students do this one at a time, as a whole group, or just ask a few. If this assembly isn't already built, this may take longer than 15 minutes.

20 Minutes (for grades 4-8):

Have students use an assembled Clawbot IQ and a small object such as a cube or tennis ball. Show the robot's arm and claw in several positions, with and without the claw holding the object, pointing out approximately where the center of gravity might be each time. Discuss how that center of gravity changes as the arm position and mass of the robot changes. Objects of varying mass could also be used as a part of the demonstration if you elect to do so. You can have students do this one at a time, as a whole group, or just ask a few. If this assembly isn't already built, this WILL take much longer than 20 minutes (see the Your First Robot unit).

30+ Minutes:

Have students complete and share the unit Idea Book Exercise, demonstrating an understanding of Mechanical Advantage and allowing for creative problem solving. This can be completed by individual students or in small groups.

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
3	Motion and Stability: Forces and Interactions	3-PS2-1	Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.	- Center of Gravity demonstrations
3	Motion and Stability: Forces and Interactions	3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.	- Unit Content Materials - Center of Gravity demonstrations
4	Energy	4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.	- Unit Content Materials - Idea Book Exercise
5	Motion and Stability: Forces and Interactions	5-PS2	Support an argument that the gravitational force exerted by Earth on objects is directed down.	- Unit Content Materials - Center of Gravity demonstrations
3-5	Engineering Design	3-5-ETS-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	- Idea Book Exercise

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.H	6-8	Students will develop an understanding of the characteristics and scope of technology.	Technology is closely linked to creativity, which has resulted in innovation.	- Idea Book Exercise
3.C	3-5	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	Various relationships exist between technology and other fields of study.	- Unit Content Materials - Matching Exercise - Clawbot IQ Center of Gravity demo - Idea Book Exercise
3.F	6-8	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.	- Unit Content Materials - Matching Exercise - Center of Gravity demonstrations - Idea Book Exercise
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	- Idea Book Exercise
8.D	3-5	Students will develop an understanding of the attributes of design.	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.	- Idea Book Exercise

F.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
8.G	6-8	Students will develop an understanding of the attributes of design.	Requirements for a design are made up of criteria and constraints.	- Idea Book Exercise
9.D	3-5	Students will develop an understanding of engineering design.	When designing an object, it is important to be creative and consider all ideas.	- Idea Book Exercise
9.G	6-8	Students will develop an understanding of engineering design.	Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.	- Idea Book Exercise
10.D	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention and innovation are creative ways to turn ideas into real things.	- Idea Book Exercise
10.G	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.	- Idea Book Exercise
11.D	3-5	Students will develop abilities to apply the design process.	Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem.	- Idea Book Exercise
11.J	6-8	Students will develop abilities to apply the design process.	Make two-dimensional and three-dimensional representations of the designed solution.	- Idea Book Exercise
16.D	3-5	Students will develop an understanding of and be able to select and use energy and power technologies.	Tools, machines, products, and systems use energy in order to do work.	- Unit Content Materials - Matching Exercise
16.E	6-8	Students will develop an understanding of and be able to select and use energy and power technologies.	Energy is the capacity to do work.	- Unit Content Materials - Matching Exercise
16.G	6-8	Students will develop an understanding of and be able to select and use energy and power technologies.	Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.	- Unit Content Materials - Matching Exercise



Common Core Standards for Mathematics (CCSM)

Teachers may (and are encouraged to) develop additional activities for this unit involving equations and calculations in conjunction with this unit to directly target specific Mathematics standards of interest or need.

F.t4 ANSWER KEY

Key Concepts Matching Exercise

Student Name(s): _____

Teacher/Class: _____ Date: _____

Instructions:

Match terms from the word bank to the correct definition by writing terms on the correct line. Each term is only used once.

Word Bank:

Center of Gravity	Feet per Second	Friction	Inch-Pounds
Inverse	Speed	Weight	Mechanical Advantage
Torque	Position	Watts	Power

Friction is the force that resists motion when one object rubs against another.

Center of Gravity is the place in a system or body where the weight is evenly distributed and all sides are in balance.

Center of Gravity uses both weight and position.

Speed is a measure of how fast an object is moving.

Torque is a force directed in a circle, most often rotating an object.

Power is the rate at which work is done.

Speed is measured in Miles per Hour or Feet per Second.

Torque is measured in units of force × distance, such as Inch-Pounds or Newton-Meters.

Power is most commonly measured in Watts.

In Classical Mechanics, speed and torque have an inverse relationship.

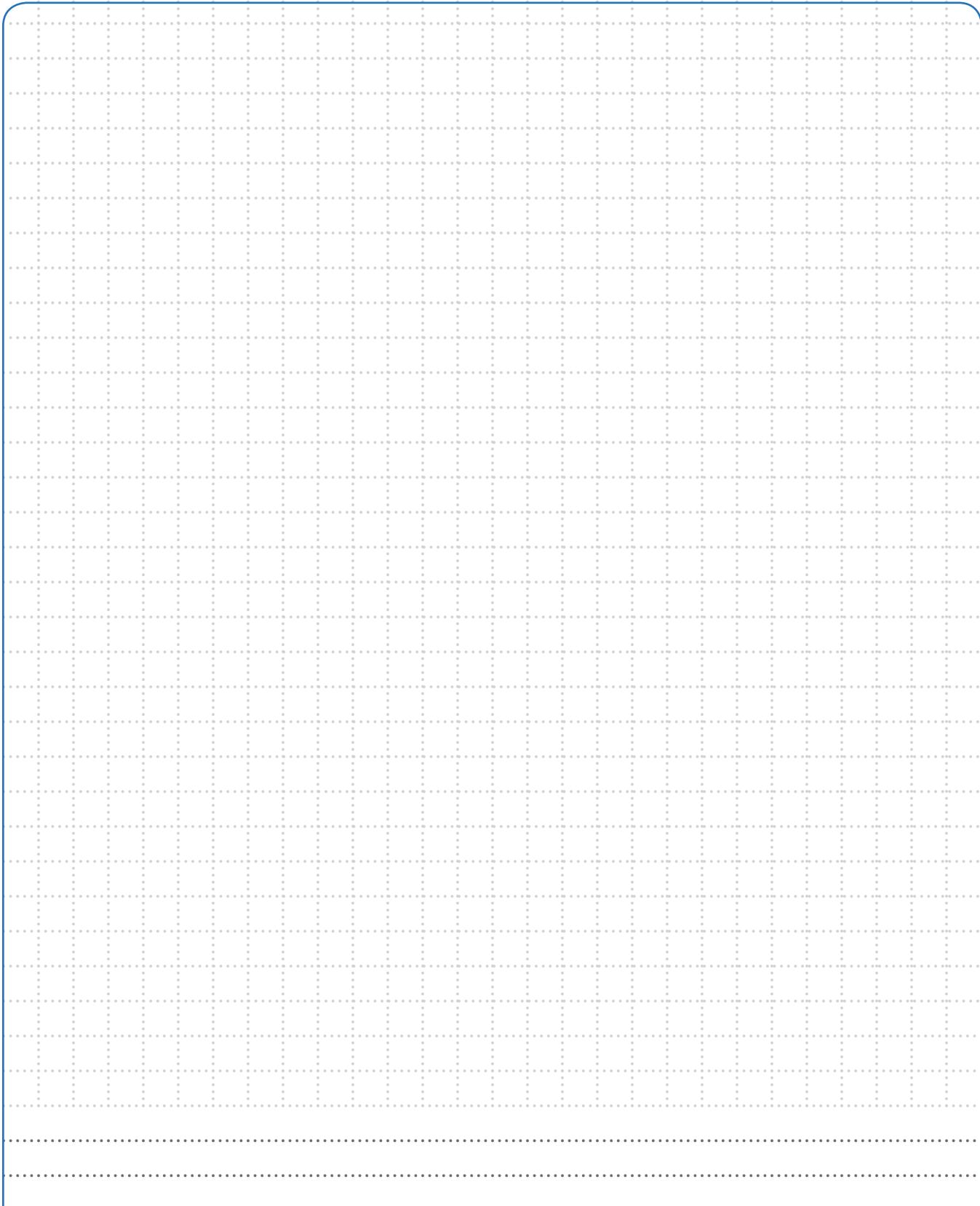
Mechanical Advantage is the calculation of how much faster and easier a machine makes your work.

Unit Notes

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F.t5 cont.

Unit Notes

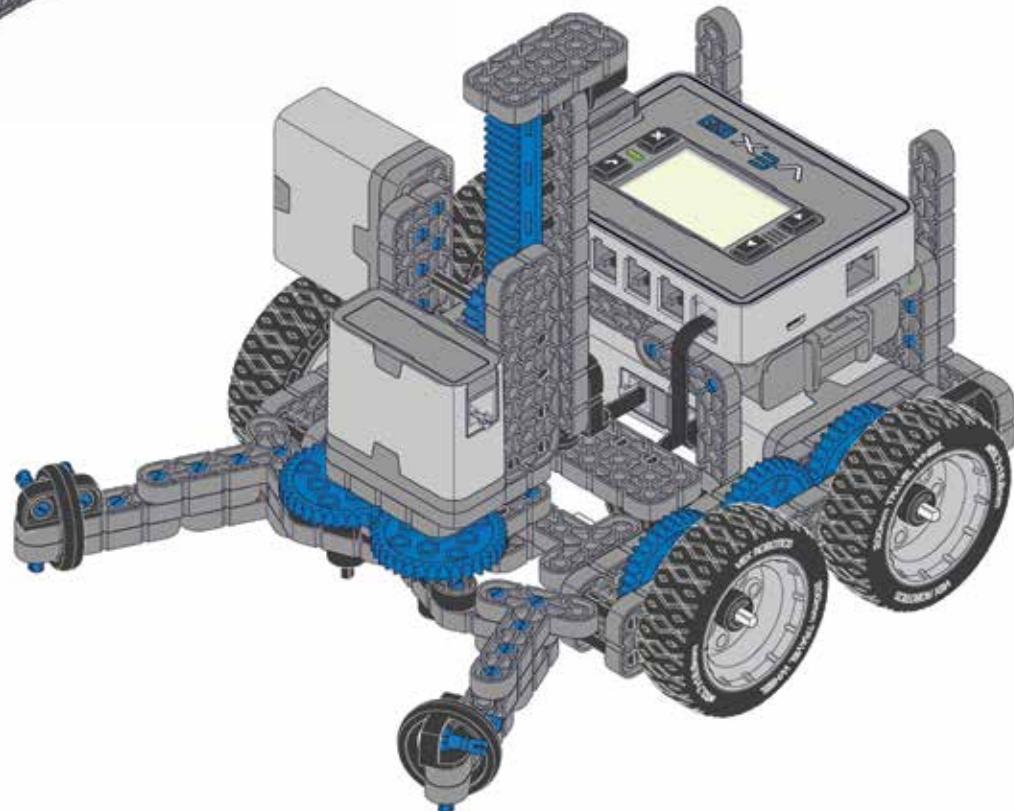
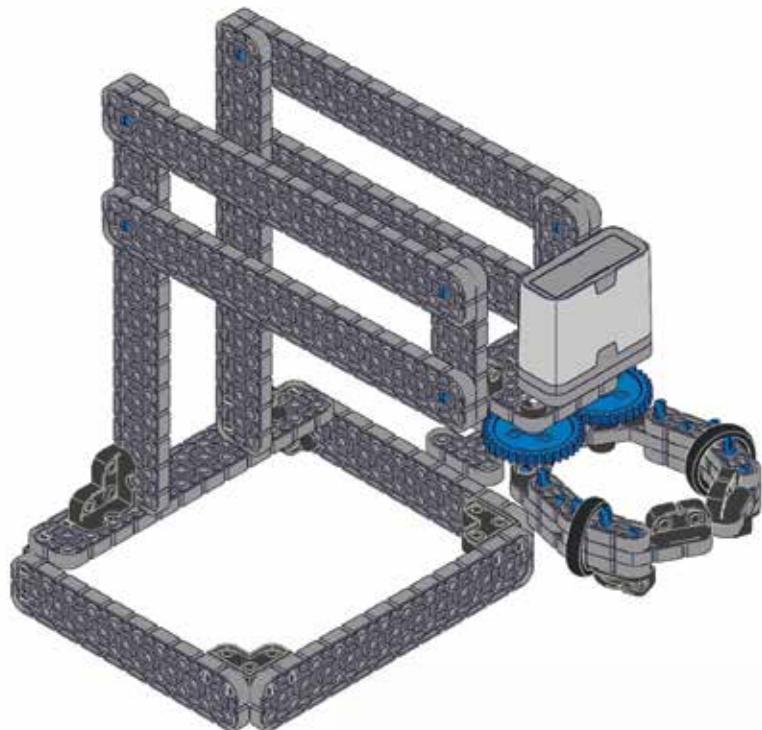


A large rectangular area filled with a grid of small, light-gray dots, designed for writing notes. The grid consists of approximately 20 horizontal rows and 30 vertical columns. The entire grid is enclosed within a thin blue rectangular border.



Mechanisms

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 2 to Grade 8

Suggested Prior Learning:

- Completion of the Let's Get Started, Simple Machines & Motion, Your First Robot, and Key Concepts units are suggested.

Unit Purpose:

The purpose of this unit is for students to learn about robotic mechanisms, their design, and the corresponding math and science concepts.

Learning Objectives:

- Students will learn about DC Motors
- Students will learn about and apply knowledge of Gear Ratio
- Students will learn about Drivetrains
- Students will learn about Object Manipulation
- Students will learn about Lifting Mechanisms
- Students will learn key terminology related to Mechanisms

Unit Vocabulary:

Accumulator Chassis	DC Motors	Degree of Freedom
Driven Gear	Driving Gear	Drivetrain Elevator
Friction Grabber	Gear Ratio	Gear Train
Idler Gear	Lifting Mechanism	Linkages
Motor Loading	Object Manipulator	Plow
Rotating Joint	Scoop	Stall
Turning Scrub	Wheelbase	

Unit Materials:

- Unit Content Material (G.1, G.2, G.3, G.4, G.5, G.6)
- Unit Written Exercises (G.7, G.9)
- Unit Build Instructions (G.8)
- Unit Written Exercises Answer Keys (G.t4, G.t5)
- Pencils or pens
- VEX IQ Kit Hardware (for Gear Ratio Simulator and other activities)
- Internet access for website use – optional
- Additional paper – optional

Unit Plan and Options

20 Minutes (for grades 4-8):

Provide students with **Mechanisms DC Motors** (G.2). Review information, terminology, and concepts related to DC Motors with the students. Additionally and optionally, use VEX IQ kit hardware to demonstrate as you review the handout.

20-45 Minutes (for grades 2-8):

Prior to learning about Gear Ratio, have students use the Gear Ratio Simulator Assembly Instructions (G.8) to build and experiment with the VEX IQ Gear Ratio Simulator. Separating out the parts required for this build prior to the activity will reduce build time. The amount of time you have to let students experiment with the simulator can also be used to adjust the time spent here.

20-45 Minutes (for grades 2-8):

Provide students with **Mechanisms Gear Ratio** (G.3). Review information, terminology, and concepts related to Gear Ratio with the students. Additionally and optionally, use VEX IQ Kit Hardware to demonstrate as you review the handout.

- For Grades 2-3: Use the Gear Ratio Basics section of this handout **ONLY**
- For Grades 4-5: Use the Gear Ratio Basics and Expressing Gear Ratio and Gear Reduction sections of this handout
- For Grades 6-8: Use **ALL** sections of this handout

20 Minutes – 1 Hour (for grades 2-8):

Provide students with **Mechanisms Gear Ratio** (G.3), the previously built Gear Ratio Simulator with extra gears, and Gear Ratio Exercise handouts 1, 2, 3, and 4 (G.9). Students should use the simulator and refer to "**Mechanisms Gear Ratio (G.3)**" as needed while they complete the Gear Ratio Exercises. Time will vary based on grade level and number of exercises used.

- For Grades 2-3: Use Gear Ratio Exercise 1 **ONLY**
- For Grades 4-5: Use Gear Ratio Exercises 1 and 2
- For Grades 6-8: Use **ALL** four Gear Ratio Exercises

20 Minutes (for grades 4-8):

Provide students with **Mechanisms Drivetrains** (G.4). Review information, terminology, and concepts related to Drivetrains with the students. Additionally and optionally, use VEX IQ kit hardware to demonstrate as you review the handout

20 Minutes (for grades 4-8):

Provide students with **Mechanisms Object Manipulation** (G.5). Review information, terminology, and concepts related to Object Manipulation with the students. Additionally and optionally, use VEX IQ kit hardware to demonstrate as you review the handout.

30 Minutes (for grades 4-8):

Provide students with **Mechanisms Lifting Mechanisms** (G.6). Review information, terminology, and concepts related to Lifting Mechanisms with the students. Additionally and optionally, use VEX IQ kit hardware to demonstrate as you review the handout.

G.t2 cont.

30 Minutes – 1 Hour (for grades 2-8):

Provide students with Matching Exercise handout for the unit. Students match terms with appropriate definitions and phrases in groups, alone, and/or for a quiz grade. Time may vary based on grade level, how many sections of the exercise you choose to have students complete, and/or how many of their resources the students are allowed to use while completing the exercise.

1+ Hour (Optional Activity for grades 4-8):

Using VEX IQ Hardware, have students build and test drivetrains, object manipulators, and/or lifting mechanisms according to specifications of activities you develop. Other build activities in subsequent units can/will suffice for this same purpose as well.

G.t3 cont.

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
3	Motion and Stability: Forces and Interactions	3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.	- Object Manipulation - Lifting Mechanisms
3-5	Engineering Design	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.	- Gear Ratio Simulator and Gear Ratio Exercises

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
2.F	3-5	Students will develop an understanding of the core concepts of technology.	A subsystem is a system that operates as a part of another system.	- Drivetrains - Object Manipulators - Lifting Mechanisms
2.K	3-5	Students will develop an understanding of the core concepts of technology.	Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.	- Drivetrains - Object Manipulators - Lifting Mechanisms
2.S	6-8	Students will develop an understanding of the core concepts of technology.	Trade-off is a decision process recognizing the need for careful compromises among competing factors.	- Gear Ratio and relationship between Speed and Torque
3.C	3-5	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	Various relationships exist between technology and other fields of study.	- Gear Ratio Simulator use and calculations - Scientific principles in unit content materials

G.t3 cont.

Common Core Standards for Mathematics (CCSM)

Domain #	Grade	Cluster	Standard	Unit Activities
4.OA	4	Operations and Algebraic Thinking	Gain familiarity with factors and multiples	- Gear Ratio and Reduction
4.NBT	4	Number and Operations in Base Ten	Use place value understanding and properties of operations to perform multi-digit arithmetic.	- Gear Ratio and Reduction
4.NF	4	Number and Operations - Fractions	Extend understanding of fraction equivalence and ordering.	- Gear Ratio and Reduction
6.RP	6	Ratios and Proportional Relationships	Understand ratio concepts and use ratio reasoning to solve problems.	- Gear Ratio and Reduction
6.NS	6	The Number System	Compute fluently with multi-digit numbers and find common factors and multiples.	- Compound Gear Reduction

G.t4 ANSWER KEY

Mechanisms Matching Exercise

Student Name(s): _____

Teacher/Class: _____ Date: _____

Instructions:

Match terms from the word bank to the correct definition by writing terms on the correct line.
Each term is only used once.

Word Bank:

Accumulator	Chassis	DC Motors
Gear Train	Degree of Freedom	Driven Gear
Driving Gear	Friction Grabbers	Drivetrain Elevator
Gear Ratio	Idler Gears	Lifting Mechanism
Object Manipulator	Linkages	Motor Loading
Plows	Rotating Joint	Scoop
Stalls	Turning Scrub	Wheelbase

From DC Motors (grades 4-8):

DC Motors convert electrical energy into mechanical energy through the use of electro-magnetic fields and rotating wire coils.

Motor Loading happens when there is any opposing force (such as friction or a heavy mass) acting as a load and requiring the motor to output torque to overcome it.

If you keep increasing the load on a motor, it will eventually stop spinning or **stalls**.

From Gear Ratio (grades 2-8):

Gear Ratio expresses the relationship between a Driving Gear and a Driven Gear in a system.

A **Driving Gear** is the gear connected to the input power source, such as a motor.

A **Driven Gear** is the gear connected to the output, such as a wheel or mechanism in a system.

A simple **Gear Train** is a connected set of rotating gears that transmits power from an input to an output.

All gears in between the Driving Gear and the Driven Gear that only transmit power are known as **Idler Gears**.

From Drivetrains (grades 4-8):

The robotic subsystem that provides the ability to move is often known as a **Drivetrain**.

A **Chassis** is the structure of a mobile robot that holds wheels, motors, and/or any other hardware used to make up a Drivetrain.

Turning Scrub is the friction that resists turning.

The **Wheelbase** is the distance between Drivetrain wheels.

G.t4 cont.

From Object Manipulation (grades 4-8):

An [Object Manipulator](#) is a mechanism that allows a robot to interact with objects in its environment.

[Plows](#) move objects without actually picking them up. They are by far the easiest manipulator type to design and build.

A [Scoop](#) applies force underneath an object such that the object can be elevated and carried.

[Friction Grabbers](#) apply a force to an object in at least two places, allowing the object to be pinched or grabbed.

Any specialized Object Manipulator designed to collect and hold multiple objects at one time is known as an [Accumulator](#).

From Lifting Mechanisms (grades 4-8):

A [Degree of Freedom](#) refers to an object's ability to move in a single independent direction of motion.

A [Lifting Mechanism](#) is any mechanism designed to move to perform tasks and/or lift objects.

The most frequently used lifting mechanism in mobile and competition robotics is a [Rotating Joint](#).

An [Elevator](#) uses linear (straight line) motion to lift straight up.

[Linkages](#) convert an input motion into a different type of output motion.

G.t5 ANSWER KEY

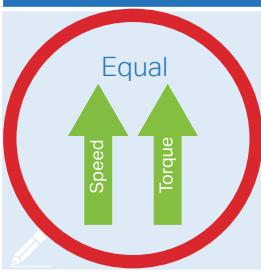
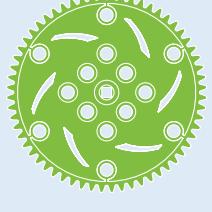
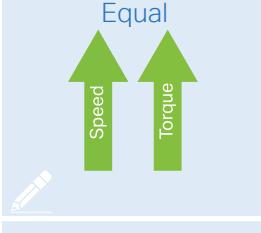
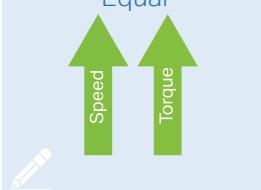
Mechanisms Gear Ratio Exercise #1: Gear Ratio Basics (Grades 2-8)

Student Name(s): _____

Teacher/Class: _____ Date: _____

Instructions:

After learning about Gear Ratios from section G.3, demonstrate what you have learned by circling correct answers below. You may also build and use the VEX IQ Gear Ratio Simulator along with 12-tooth, 36-tooth, and 60-tooth gears to help find answers.

Driving Gear (Input)	Driven Gear (Output)	What does this ratio create when comparing output to input? (Circle the correct answer below)		
36-tooth 	36-tooth 	 Equal	  	  
12-tooth 	60-tooth 	 Equal	  	  
36-tooth 	12-tooth 	 Equal	  	  
12-tooth 	36-tooth 	 Equal	  	  
60-tooth 	12-tooth 	 Equal	  	  

G.t5 cont. **ANSWER KEY**

Mechanisms Gear Ratio Exercise #2: Expressing Ratio and Reduction (Grades 4-8)

Student Name(s): _____

Teacher/Class: _____ Date: _____

Instructions:

After learning about Expressing Gear Ratio and Gear Reduction from section G.3, demonstrate what you have learned by calculating and writing in correct answers. You may also build and use the VEX IQ Gear Ratio Simulator along with 12-tooth, 36-tooth, and 60-tooth gears to help find answers.

Driving Gear (Input)	Driven Gear (Output)	Gear Ratio	Gear Reduction	Simplified Gear Reduction	Is Speed or Torque increased?
36-tooth 	36-tooth 	<u>36:36</u>	<u>36/36</u>	<u>1/1</u>	<u>Neither one is increased</u>
12-tooth 	60-tooth 	<u>12:60</u>	<u>60/12</u>	<u>5/1</u>	<u>Torque</u>
36-tooth 	12-tooth 	<u>36:12</u>	<u>12/36</u>	<u>1/3</u>	<u>Speed</u>
36-tooth 	60-tooth 	<u>36:60</u>	<u>60/36</u>	<u>1.67/1</u>	<u>Torque</u>
60-tooth 	12-tooth 	<u>60:12</u>	<u>12/60</u>	<u>1/5</u>	<u>Speed</u>

G.t5 cont. ANSWER KEY

Mechanisms Gear Ratio Exercise #2: Expressing Ratio and Reduction (Grades 4-8)

Student Name(s): _____

Teacher/Class: _____ Date: _____

Instructions:

After learning about Gear Trains and Idler Gears from section G.3, demonstrate what you have learned by calculating and writing in correct answers. You may also build and use the VEX IQ Gear Ratio Simulator along with 12-tooth, 36-tooth, and 60-tooth kit gears to help find answers.

Driving Gear (Input)	Idler Gear	Driven Gear (Output)	Gear Ratio	Gear Reduction	Simplified Gear Reduction
36-tooth 	60-tooth 	36-tooth 	<u>36:36</u> 	<u>36/36</u> 	<u>1/1</u> 
12-tooth 	36-tooth 	60-tooth 	<u>12:60</u> 	<u>60/12</u> 	<u>5/1</u> 
36-tooth 	12-tooth 	60-tooth 	<u>36:60</u> 	<u>60/36</u> 	<u>1.67/1</u> 
12-tooth 	36-tooth 	36-tooth 	<u>12:36</u> 	<u>36/12</u> 	<u>3/1</u> 
12-tooth 	36-tooth and 36-tooth 	60-tooth 	<u>12:60</u> 	<u>60/12</u> 	<u>5/1</u> 

G.t5 cont. ANSWER KEY

Mechanisms Gear Ratio Exercise #4: Compound Gear Reductions (Grades 6-8)

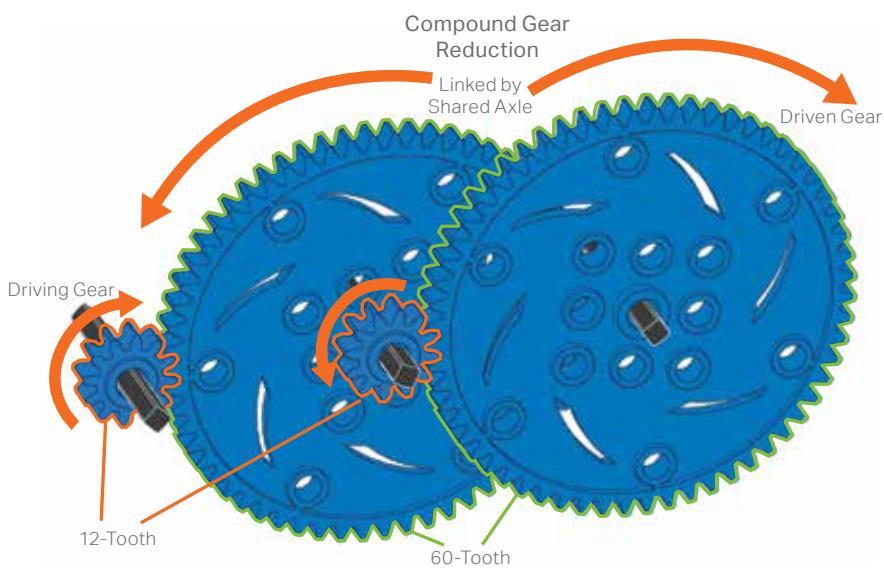
Student Name(s): _____

Teacher/Class: _____ Date: _____

Review of Key Points:

In a Compound Gear system, there are multiple gear pairs. Each pair has its own Gear Ratio, and a shared axle connects the pairs to each other. The resulting Compound Gear system still has a Driving Gear and a Driven Gear, and still has a Gear Reduction. However, it is now called a Compound Gear Reduction that is calculated by multiplying the gear reductions of each of the individual gear pairs.

For the example shown with 12-tooth and 60-tooth gears, the overall Gear Reduction is calculated this way:



$$\begin{matrix} (60 / 12) \\ (5 / 1) \end{matrix} \times \begin{matrix} (60 / 12) \\ (5 / 1) \end{matrix} = 25 / 1$$



Say "25 to 1 Compound Gear Reduction"

Instructions:

Using the information above from Compound Gears and Compound Gear Reductions (G.3), demonstrate what you have learned by calculating the correct Compound Gear Reductions. You may also build and use the VEX IQ Gear Ratio Simulator along with 12-tooth, 36-tooth, and 60-tooth kit gears to help find answers.

Gear Pair 1		Gear Pair 2		Simplified Reduction 1	Simplified Reduction 2	Compound Gear Reduction
Driving Gear 1	Driven Gear 1	Driving Gear 2	Driven Gear 2			
12-tooth 	60-tooth 	12-tooth 	36-tooth 	<u>5/1</u> 	<u>3/1</u> 	<u>15/1</u>
12-tooth 	36-tooth 	12-tooth 	36-tooth 	<u>3/1</u> 	<u>3/1</u> 	<u>9/1</u>
12-tooth 	36-tooth 	12-tooth 	60-tooth 	<u>3/1</u> 	<u>5/1</u> 	<u>15/1</u>

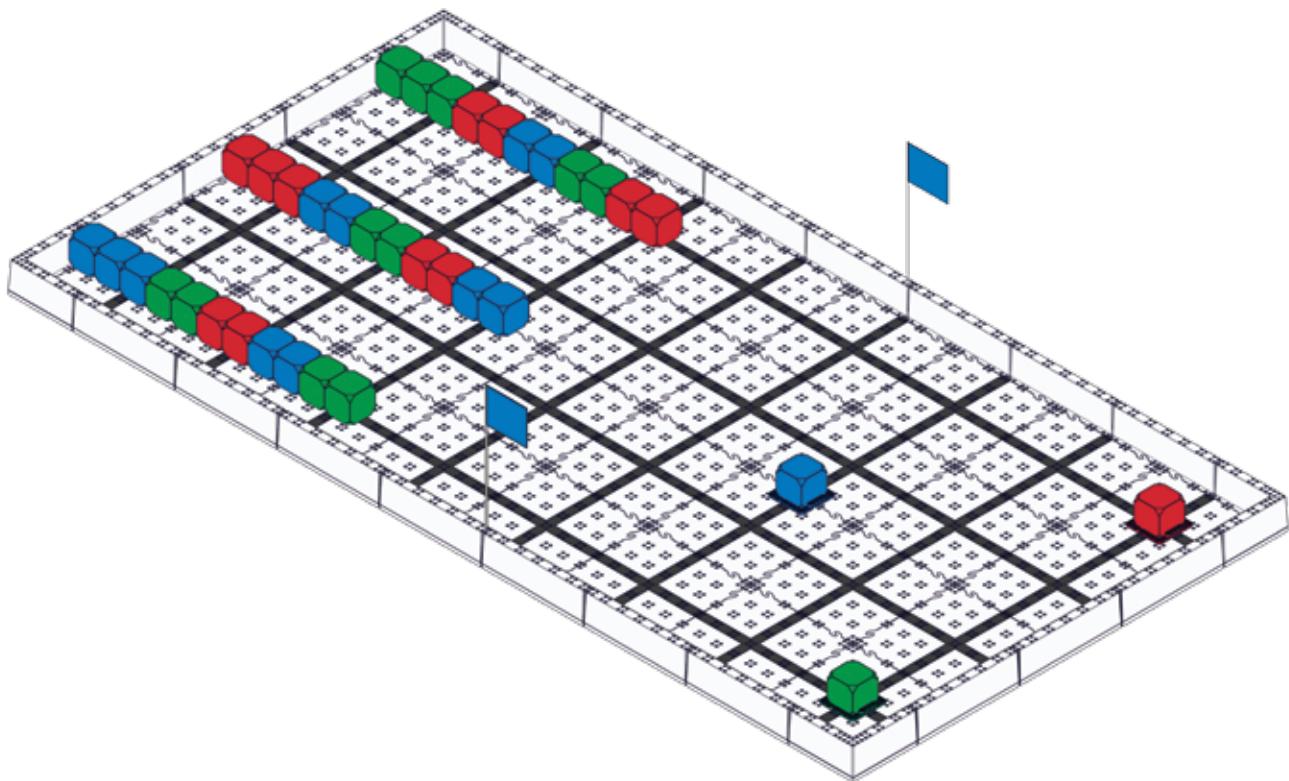
G.t6

Unit Notes



Highrise Challenge

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 4 to Grade 8

Suggested Prior Learning:

- Completion of the Let's Get Started & Your First Robot units are suggested
- Additionally, completion of the Key Concepts & Mechanisms units would be very helpful

Unit Purpose:

The purpose of this unit is for students to design and build a challenge-ready teleoperated robot for the Highrise Challenge (or similar teleoperated challenge designed by the teacher).

Learning Objectives:

- Students will utilize the design process
- Students will document design
- Students will be able to troubleshoot and solve problems to improve design
- Students will participate in the Highrise (or similar) Challenge

Additional Purpose(s)/Objectives:

If desired, teachers can add additional content-specific purposes and objectives to any open-ended robotics challenge (like this unit provides) to develop corresponding targeted lessons around specific science, technology, and math content.

Unit Vocabulary:

Engineering Notebook

Control System

Electrical System

Mechanical System

Unit Materials:

- Unit Content Material (H.1, H.2, H.3)
- Unit Rubric (H.4)
- Unit Written Exercise (H.5)
- Challenge rules and game documentation
- Pencils or pens
- VEX IQ Robot Brain, Controller, and kit hardware
- Highrise Field & Game Elements (or equivalent for alternate game challenge)
- VEX IQ Challenge Full Field Perimeter & Tiles (or equivalent)
- Internet access for website use – optional
- Additional paper – optional

Unit Plan and Options

20 Minutes:

Introduce Game and Field to students. Provide copies of rules and corresponding documentation.

30 Minutes:

Lead a brainstorming activity with student teams (large group or small) to generate ideas on how to best play the game (strategy) and what kind of robot can achieve a set of desired goals. Use Idea Book pages or Engineering Notebook during this process.



If some groups claim to be done quickly, challenge them to brainstorm further. Sometimes students will gravitate toward the first idea they come up with, rather than going through a full brainstorming phase. Remind them that this is the most important part of the engineering process; the first solution they jump toward is rarely the best one.

30 Minutes:

From the brainstorming lists, student teams should choose their desired strategy and sketch/describe what that robot might look like on their Idea Book page (H.5) or in their Engineering Notebook.

5+ Hours:

Over several days/weeks student teams design, build, and test their teleoperated robot for the given challenge using the "THINK-DO-TEST" approach to completing their Idea Book pages or Engineering Notebook entries all while building within the constraints of the challenge rules. Use the Robot Challenge Evaluation Rubric as a vehicle for improvement during the process and/or to assess final designs. Idea Book pages / Engineering Notebooks are part of the rubric, but can also be assessed for a grade separately if desired.

2+ Hours:

Have students compete in the challenge within the classroom OR attend/hold an official VEX IQ Challenge event (see www.robotevents.com for details). Ideas for a fun, exciting classroom event:

- Announce matches
- Use A/V displays for scores, pictures, and more
- Invite your principal, parents, and/or STEM-connected adults from the community
- Provide awards in several categories just like official events (on field scores, design, teamwork, and more)
- Invite outside adults/school officials to be referees or judges and interview students about their designs and process
- Celebrate effort and results

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
4	Energy	4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
4	Energy	4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
3-5	Engineering Design	3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
3-5	Engineering Design	3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
3-5	Engineering Design	3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
6-8	Energy	MS-PS3-5	Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.	- Challenge Robot Build - Idea Book Pages/ Engineering. Notebook
6-8	Engineering Design	MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	- Challenge Robot Build - Idea Book Pages/ Engineering. Notebook
6-8	Engineering Design	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.	- Challenge Robot Build - Idea Book Pages/ Engineering. Notebook
6-8	Engineering Design	MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	- Challenge Robot Build - Idea Book Pages/ Engineering. Notebook

H.t3 cont.

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
1.G	6-8	Students will develop an understanding of the characteristics and scope of technology.	The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
2.G	3-5	Students will develop an understanding of the characteristics and scope of technology.	When parts of a system are missing, it may not work as planned.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
2.L	3-5	Students will develop an understanding of the characteristics and scope of technology.	Requirements are the limits to designing or making a product or system.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
2.Q	6-8	Students will develop an understanding of the characteristics and scope of technology.	Malfunctions of any part of a system may affect the function and quality of the system.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
2.R	6-8	Students will develop an understanding of the characteristics and scope of technology.	Requirements are the parameters placed on the development of a product or system.	- Following Challenge Rules
2.U	6-8	Students will develop an understanding of the characteristics and scope of technology.	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
8.D	3-5	Students will develop an understanding of the attributes of design.	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.	- Following Challenge Rules
8.F	6-8	Students will develop an understanding of the attributes of design.	There is no perfect design.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
8.G	6-8	Students will develop an understanding of the attributes of design.	Requirements for a design are made up of criteria and constraints.	- Following Challenge Rules

H.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
9.C	3-5	Students will develop an understanding of engineering design.	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
9.D	3-5	Students will develop an understanding of engineering design.	When designing an object, it is important to be creative and consider all ideas.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
9.F	6-8	Students will develop an understanding of engineering design.	Design involves a set of steps, which can be performed in different sequences and repeated as needed.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
9.G	6-8	Students will develop an understanding of engineering design.	Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.	- Idea Book Pages/ Engineering Notebook
10.C	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a way of finding out why something does not work so that it can be fixed.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
10.D	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention and innovation are creative ways to turn ideas into real things.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
10.E	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	The process of experimentation, which is common in science, can also be used to solve technological problems.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
10.F	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
10.G	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
10.H	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Some technological problems are best solved through experimentation.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
11.F	3-5	Students will develop abilities to apply the design process.	Test and evaluate the solutions for the design problem.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
11.G	3-5	Students will develop abilities to apply the design process.	Improve the design solutions.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
11.H	6-8	Students will develop abilities to apply the design process.	Apply a design process to solve problems in and beyond the laboratory-classroom.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
11.K	6-8	Students will develop abilities to apply the design process.	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook

Common Core Standards for Mathematics (CCSM)

Domain #	Grade	Cluster	Standard	Unit Activities
4.OA	4	Operations and Algebraic Thinking	Use the four operations with whole numbers to solve problems.	- Idea Book Pages/ Engineering Notebook
4.MD	4	Measurement and Data	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	- Idea Book Pages/ Engineering Notebook
4.MD	4	Measurement and Data	Represent and interpret data.	- Idea Book Pages/ Engineering Notebook
6.EE	6	Expressions and Equations	Represent and analyze quantitative relationships between dependent and independent variables.	- Idea Book Pages/ Engineering Notebook
7.RP	7	Ratios and Proportional Relationships	Analyze proportional relationships and use them to solve real-world and mathematical problems.	- Idea Book Pages/ Engineering Notebook



NOTE: Given the nature of an open-ended robotics challenge like the one in this unit of study, it's not feasible to list all possible standards connections. The standards listed above are only samples and a fraction of what can be accomplished with this unit. We encourage educators to delve deeper into the leg(s) of STEM most meaningful and useful to their students, tailoring Idea Book/Engineering Notebook entries and/or adding their own lessons where they'd like.

Areas to find/develop additional standards connections for this unit:

NGSS: Structure and Properties of Matter, Energy, Engineering Design, Forces and Interactions

STL: The Nature of Technology, Design, Abilities for a Technological World, The Designed World

CCSM: Operations and Algebraic Thinking, Number and Operations – Fractions, Measurement and Data, Geometry, Ratios and Proportional Relationships, Expressions and Equations, Statistics and Probability

H.t4

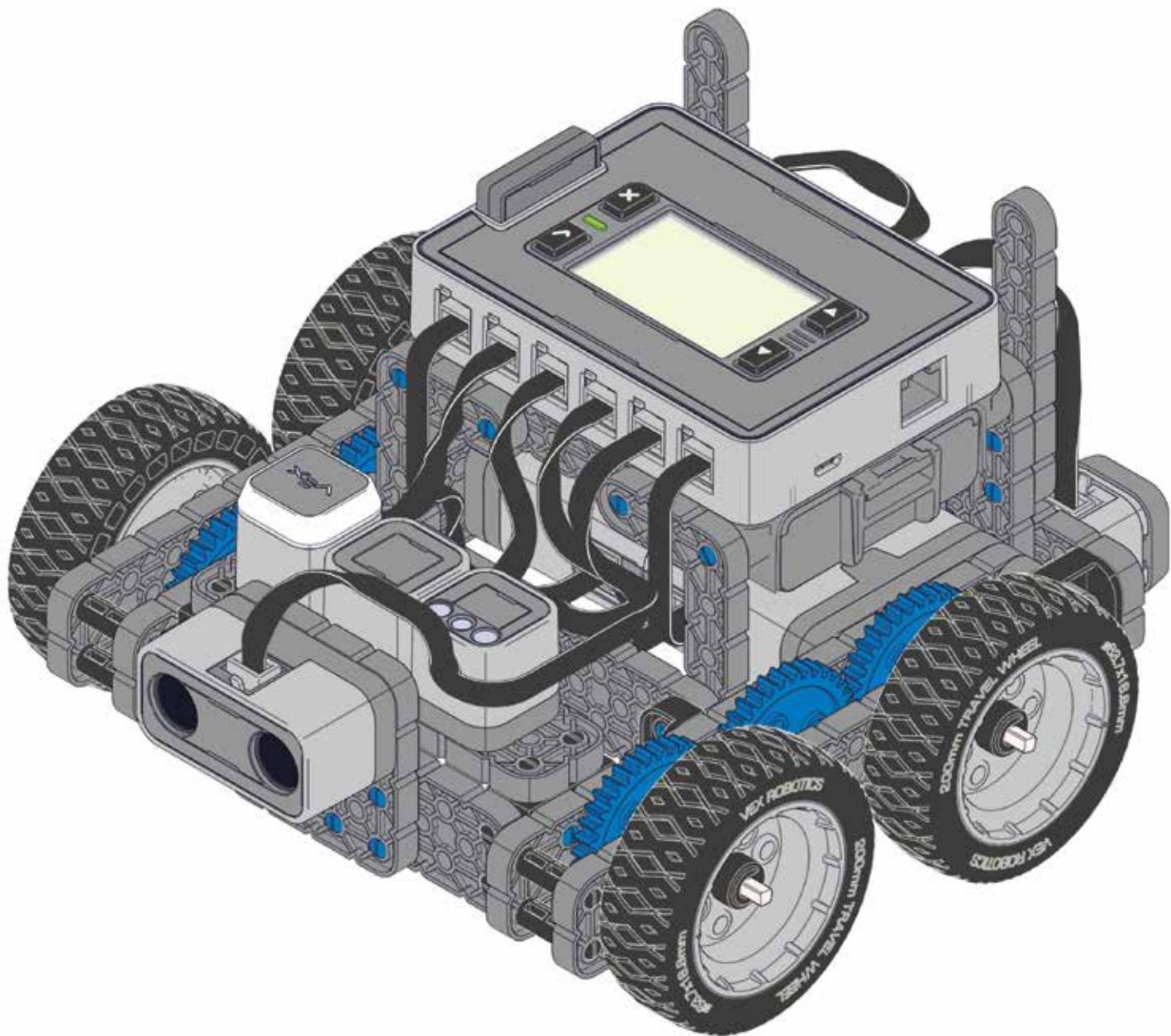
Unit Notes

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I

Smart Machines

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 4 to Grade 8

Suggested Prior Learning:

- Completion of the Let's Get Started & Your First Robot units are suggested
- Additionally, becoming familiar with your chosen VEX IQ programming software first is helpful

Unit Purpose:

The purpose of this unit is for students to become familiar with VEX IQ Sensors and their default functionality. A brief introduction to programming with VEX IQ is also included.

Learning Objectives:

- Students will learn key terminology related to sensors and programming
- Students will learn sensor types and capabilities
- Students will utilize design process through programming exercises
- Students will document design in Idea Book pages
- Students will be able to troubleshoot and solve problems to improve design

Unit Vocabulary:

Degrees of Turn	Encoder	Bumper Switch
Touch LED	Gyroscope	Programming
Distance Sensor	Color Sensor	Sensor
Ultrasonic Sound Waves	Gyro Sensor	Smart Motor

Unit Materials:

- Unit Content Material (I.1, I.2, I.3)
- Unit Written Exercises (I.4, I.10)
- Unit Build Instructions (I.5)
- Unit Application Exercises (I.6, I.7, I.8, I.9)
- Unit Written Exercise Answer Key (I.t4)
- Pencils or pens
- VEX IQ Robot Brain, Controller, kit hardware, and programming software
- Red, Green, and Blue objects (cards or cubes) for color sensor exercises
- Internet access for website use – optional
- Additional paper – optional

Unit Plan and Options

40 Minutes:

Read and review the Key Terms (I.2) and Sensor Overview (I.3) with students

30 Minutes:

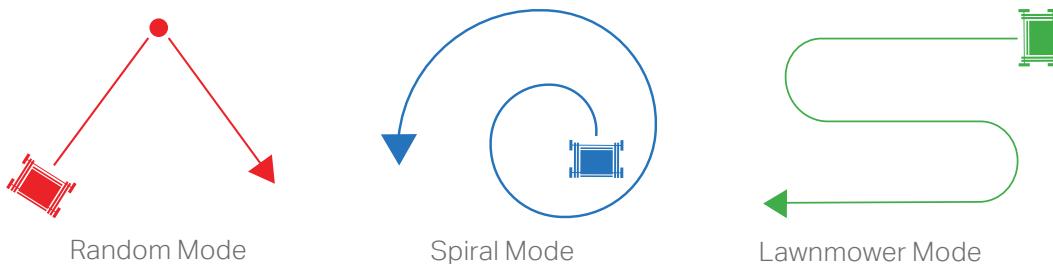
Complete the unit Matching Exercise (I.4).

20 – 60 Minutes:

Build Autopilot Robot. See the Autopilot Robot Assembly Instructions in your kit documentation. This time will vary depending on previous completion of the Standard Drive Base build.

20-40 Minutes:

Use Autopilot Robot to run the three Autopilot Modes. These are demonstrations of different ways Sensors can work together in a Smart Machine. See your kit documentation for details. Time will vary based on how you decide to explore/demonstrate these modes.



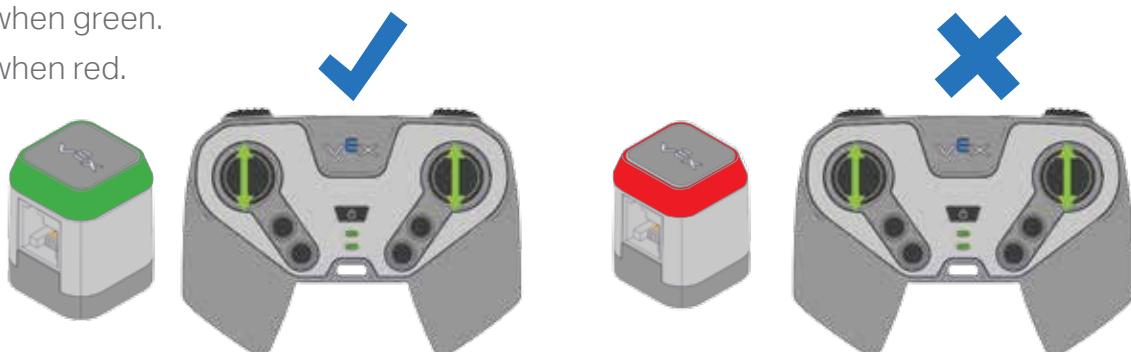
20-30 Minutes Each:

Perform default Sensor Functionality Exercises. See your kit documentation for details in addition to information below.

Touch LED Default Functionality Exercise: "Stop and Go"

The default Touch LED functionality in the Driver Control program is to act like a traffic light for the robot. Using the Autopilot or similar robot with ONLY Smart Motors and a Touch LED connected to any unused port in the Robot Brain:

- Turn ON the Robot Brain and Controller.
- Select and run the Driver Control program.
- The robot starts in enabled mode with the Touch LED glowing green. Tap the top dome of the Touch LED to change between enabled (glowing green) and disabled (glowing red).
- Try to drive when green.
- Try to drive when red.

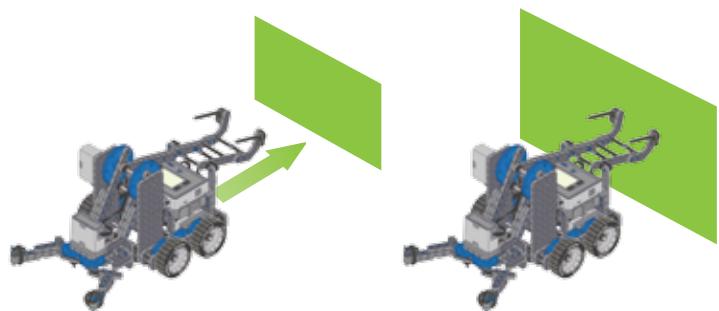


I.t2 cont.

Distance Sensor Default Functionality Exercise: "Collision Avoidance"

The default Distance Sensor functionality in the Driver Control program is to prevent a robot from running into an object or wall. When the Distance Sensor sees an object, it will slow down the Autopilot Robot as it approaches the object, eventually stopping to avoid collision. Using the Autopilot or similar robot with ONLY Smart Motors and a Distance Sensor connected to any unused port in the Robot Brain:

- Turn ON the Robot Brain and Controller.
- Select and run the Driver Control program.
- Use the Controller to drive the robot toward a wall. When the Distance Sensor sees an object that is too close to the robot, it will stop the robot from hitting that object.



Color Sensor Default Functionality Exercise: "Red Light, Green Light"

The default Color Sensor functionality in the Driver Control program is to act like a traffic light for the robot, much like the Touch LED. When the Color Sensor "sees" a green card (or other object) you can drive the robot. When it "sees" a red card (or other object) you cannot drive the robot. Using the Autopilot or similar robot with ONLY Smart Motors and a Color Sensor connected to any unused port in the Robot Brain:

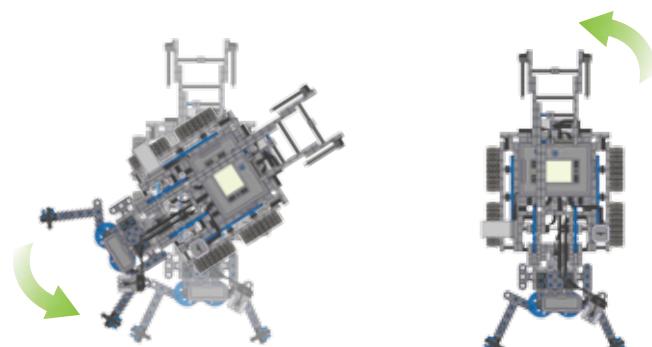


- Turn ON the Robot Brain and Controller.
- Select and run the Driver Control program.
- The robot will start in enabled mode. When a red card or object is shown in front of the color sensor, the robot will be disabled. When a green card is shown in front of the color sensor, the robot will be enabled.

Gyro Sensor Default Functionality Exercise: "Home Direction"

The default Gyro Sensor functionality in the Driver Control program is to keep the robot pointed in the same direction when not being driven by the Controller. If a robot is pushed or spun by anything other than being driven by the Controller, the robot will use the Gyro Sensor to measure how much it spun. The robot will then automatically spin back to the original direction it was pointing. Using the Autopilot or similar robot with ONLY Smart Motors and a Gyro Sensor connected to any unused port in the Robot Brain:

- Turn ON the Robot Brain and Controller.
- Select and run the Driver Control program.
- Use the Controller turn the Robot to a new direction. When you stop driving, the robot will automatically turn back to the original direction.



I.t2 cont.

20-40 Minutes: Simple Programming Exercises using only the Robot Brain

You can make some changes to the way a robot is programmed by making simple configuration changes using only the LED screen and buttons on the VEX IQ Robot Brain. Please use your User Guide and follow instructions to make configuration changes, testing out each change.

30 Minutes -1 Hour Each: Simple Programming Exercises Using Programming Software

Before you complete any of the exercises below, you will need to:

1. RETURN THE DRIVER CONTROL PROGRAM TO ITS DEFAULT SETTINGS.
2. Become familiar with programming software. Specifically, students should be able to open and use the programming software, save custom programs, connect the programming computer to their VEX IQ robot, successfully transfer custom programs to the Robot Brain, and run custom programs after they are transferred. You should decide the best way to get your students comfortable with the programming software.



Notes: All of the possible exercises below utilize an Autopilot or similar robot with ONLY Smart Motors and the featured sensor connected to any unused port in the Robot Brain. Be sure to use the unit Idea Book Page to plan and troubleshoot your custom programs as part of these exercises. A sample Idea Book Page is provided for reference as needed.

Possible Programming Exercises with Bumper Switch & Smart Motors:

(30 Minutes - 1 Hour Each):



1. Robot backs up autonomously to a wall until one or both of the bumper switches on the Autopilot Robot is/ are activated by the wall, stopping the robot.
2. Teacher-created exercise.

Possible Programming Exercises with Touch LED Sensor & Smart Motors:

(30 Minutes - 1 Hour Each):



1. Robot drives autonomously forward 5 motor revolutions with Touch LED glowing green.
2. LED starts out red. Tap Touch LED, it glows green and robot drives forward autonomously. Tap LED again to change it back to red and robot stops.
3. Teacher-created exercise.

Possible Programming Exercises with Distance Sensor & Smart Motors:

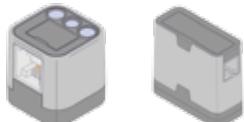
(30 Minutes - 1 Hour Each):



1. Robot drives autonomously toward a wall. Robot stops driving 6 inches from wall.
2. Robot drives autonomously toward a wall. Robot stops driving 6 inches from wall, then backs up 5 motor revolutions in return direction.
3. Teacher-created exercise.

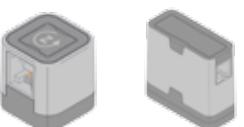
I.t2 cont.

Possible Programming Exercises with Color Sensor & Smart Motors: (30 Minutes - 1 Hour Each):



1. Robot drives autonomously forward when Color Sensor is shown a green card.
Robot stops when Color Sensor is shown a red card.
2. Robot drives autonomously forward when Color Sensor is shown a green card.
Robot drives autonomously backwards when Color Sensor is shown a blue card.
Robot stops when Color Sensor is shown a red card.
3. Teacher-created exercise.

Possible Programming Exercises with Gyro Sensor & Smart Motors: (30 Minutes - 1 Hour Each):



1. Robot drives autonomously forward 5 motor revolutions, then spins 180 degrees and stops.
2. Robot spins 90 degrees, then pauses for 5 seconds, then spins another 90 degrees, then pauses another 5 seconds, and keeps repeating the pattern until program is stopped.
3. Teacher-created exercise.

I.t3

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
3.5	Engineering Design	3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	- Programming Exercises & Idea Book documentation
3.5	Engineering Design	3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	- Programming Exercises & Idea Book documentation

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	- Default Sensor Functionality Exercises - Programming Exercises - Idea Book Pages
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	- Default Sensor Functionality Exercises - Programming Exercises - Idea Book Pages
2.G	3-5	Students will develop an understanding of the core concepts of technology.	When parts of a system are missing, it may not work as planned.	- Programming Exercises and troubleshooting

I.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
2.Q	6-8	Students will develop an understanding of the core concepts of technology.	Malfunctions of any part of a system may affect the function and quality of the system.	- Programming Exercises and troubleshooting
2.R	6-8	Students will develop an understanding of the core concepts of technology.	Requirements are the parameters placed on the development of a product or system.	- Programming Exercises
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	- Idea Book Pages with Programming Exercises
8.D	3-5	Students will develop an understanding of the attributes of design.	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.	- Programming Exercises
8.G	6-8	Students will develop an understanding of the attributes of design.	Requirements for a design are made up of criteria and constraints.	- Programming Exercises
9.C	3-5	Students will develop an understanding of engineering design.	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.	- Programming Exercises and troubleshooting - Idea Book Pages
10.C	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a way of finding out why something does not work so that it can be fixed.	- Programming Exercises and troubleshooting - Idea Book Pages
10.F	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.	- Programming Exercises and troubleshooting - Idea Book Pages
11.J	6-8	Students will develop abilities to apply the design process.	Make two-dimensional and three-dimensional representations of the designed solution.	- Programming Exercises and troubleshooting - Idea Book Pages
11.K	6-8	Students will develop abilities to apply the design process.	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	- Programming Exercises and troubleshooting - Idea Book Pages
11.L	6-8	Students will develop abilities to apply the design process.	Make a product or system and document the solution.	- Programming Exercises and troubleshooting - Idea Book Pages



Common Core Standards for Mathematics (CCSM)

Teachers may (and are encouraged to) develop additional activities for this unit involving equations, calculations, and/or algorithms to directly target specific Mathematics standards of interest or need.

I.t4 ANSWER KEY

Smart Machines Matching Exercise

Student Name(s): _____

Teacher/Class: _____ Date: _____ Page#: _____

Part I Instructions:

Match terms from the word bank to the correct definition or statement by writing terms on the correct line. Each term is only used once.

Part I Word Bank:

Degrees of Turn

Gyroscope

Sensor

Encoder

Programming

Ultrasonic Sound Waves

A(n) **Sensor** is a device that detects and responds to some type of input from the physical environment.

Programming is the process of providing a computer or other machine, such as a robot and its components, with coded instructions for the automatic performance of a particular task.

Ultrasonic Sound Waves are sounds that are too high of a frequency to be heard by humans.

A(n) **Gyroscope** is a sensor that can detect and measure rotation or turning of an object.

Degrees of Turn describes how far an object, like a robot, has turned.

A(n) **Encoder** senses mechanical motion and translates the information into useful data.

Part II Instructions:

Match terms from the word bank and label correctly below each image (images are NOT to scale).

Part II Word Bank:

Bumper Switch

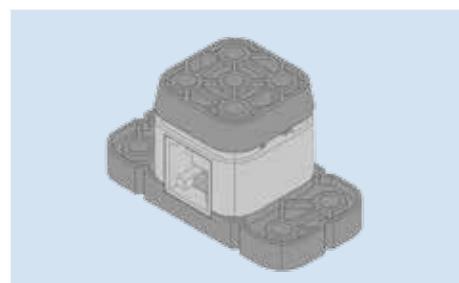
Distance Sensor

Smart Motor

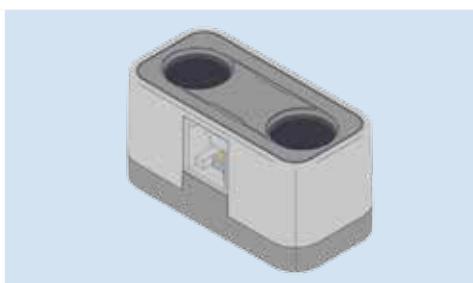
Color Sensor

Gyro Sensor

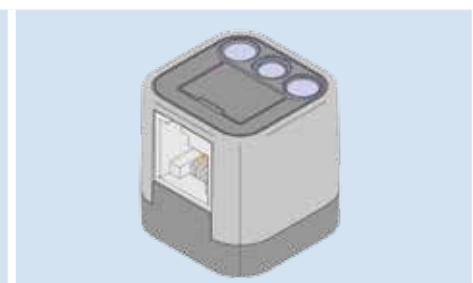
Touch LED



Bumper Switch



Distance Sensor



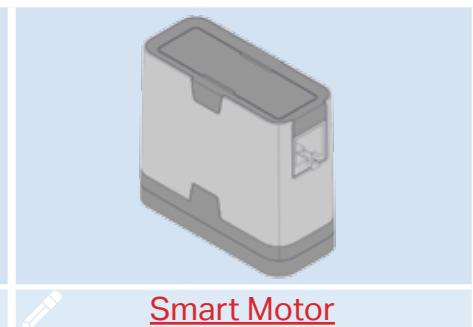
Color Sensor



Touch LED



Gyro Sensor



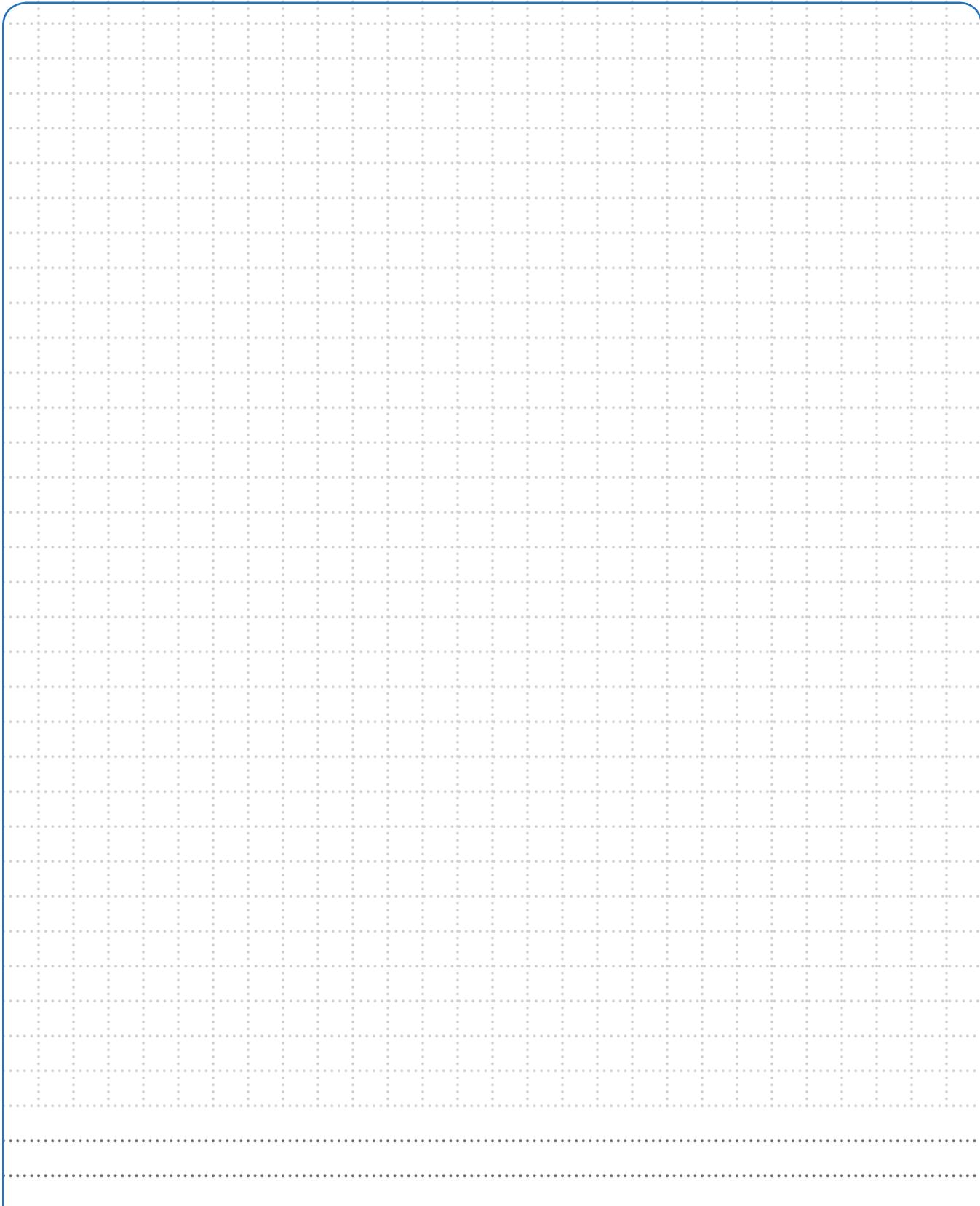
Smart Motor

Unit Notes

This image shows a blank sheet of dot-grid paper designed for note-taking. The grid consists of small, uniform dots arranged in rows and columns to provide a guide for letter height and placement. The grid is contained within a rectangular frame with rounded corners. At the bottom of the page, there are three horizontal lines: a solid top line, a dashed middle line, and a solid bottom line, which serve as a baseline for handwritten text.

I.t5 cont.

Unit Notes

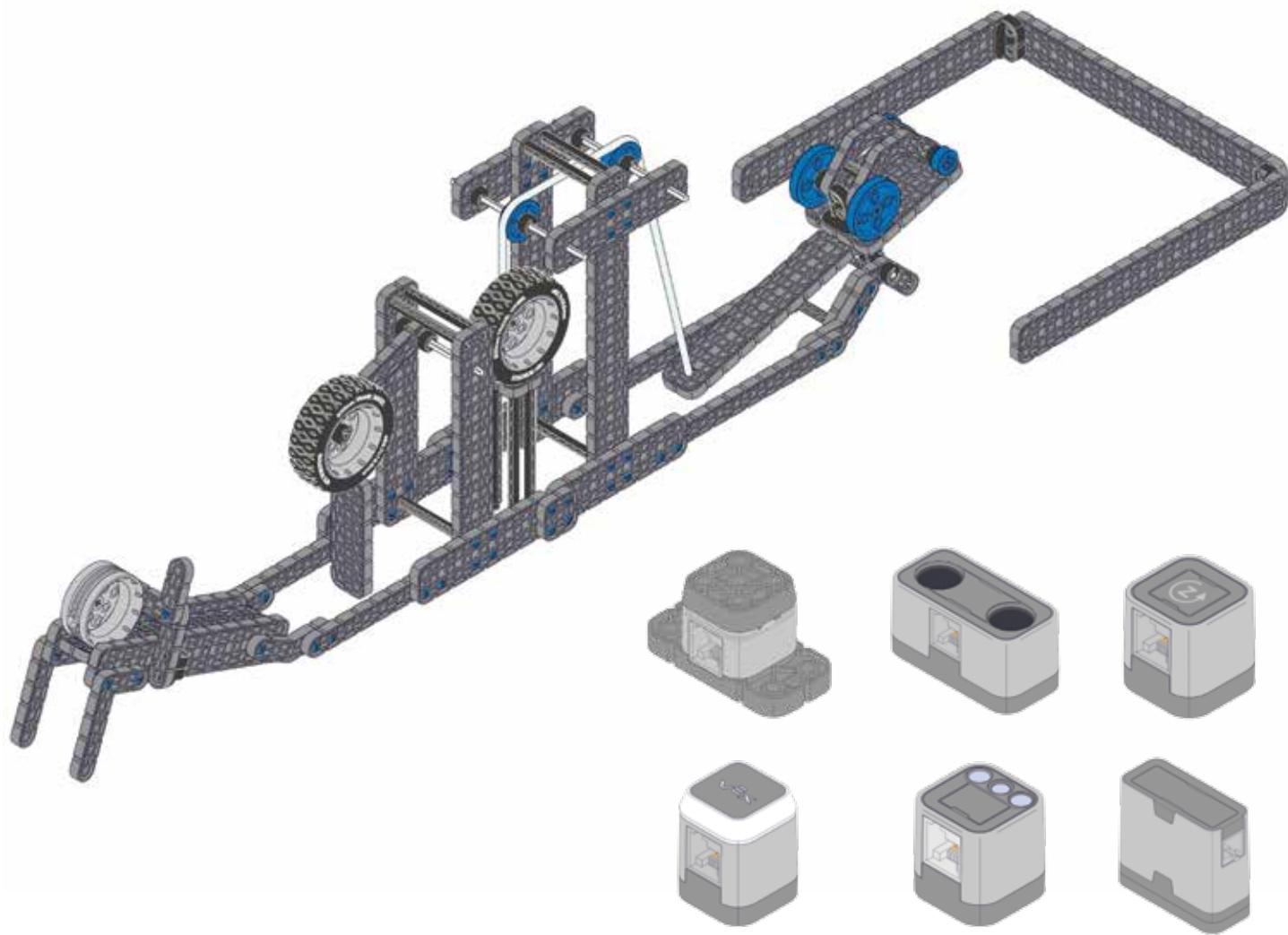


A large rectangular area filled with a grid of small, light-gray dots, designed for writing notes. The grid consists of approximately 20 horizontal rows and 30 vertical columns. The entire grid is enclosed within a thin blue rectangular border.



Chain Reaction Programming Challenge

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 2 to Grade 8

Suggested Prior Learning:

- Completion of the Chain Reaction Challenge & Smart Machines units are suggested
- Familiarity with one or more of the VEX IQ programming software options is also encouraged

Unit Purpose:

The purpose of this unit is for students to design and build a fully autonomous Chain Reaction Device to rubric specifications.

Learning Objectives:

- Students will apply knowledge of Simple Machines and Pendulums
- Students will utilize key terminology related to Chain Reaction Devices
- Students will utilize the design process to build their own Chain Reaction Device(s)
- Students will apply knowledge of VEX IQ sensors as well as programming techniques
- Students will document design
- Students will be able to troubleshoot and solve problems to improve design

Additional Purpose(s)/Objectives:

If desired, teachers can add additional content-specific purposes and objectives to any open-ended robotics challenge (like this unit provides) to develop corresponding targeted lessons around specific science, technology, math, and computer science content.

Unit Vocabulary:

Chain Reaction Device Stage

Trigger Mechanism

Autonomous

Sensor

Programming

Unit Materials:

- Unit Content Material (J.1, J.2)
- Unit Rubrics (J.3)
- Unit Written Exercise (J.4)
- Pencils or pens
- VEX IQ Robot Brain, kit hardware, sensors, and programming software
- String (optional, for pulley assemblies, etc.)
- Internet access for website use – optional
- Additional paper – optional

Unit Plan and Options

20 Minutes:

Review information, terminology, and definitions related to Chain Reactions in this or previous units, as well as terminology related to autonomous robots and programming from previous units as necessary.

15 Minutes:

Review the **Chain Reaction Programming Challenge** Rules (J.2) with student teams. The challenge is designed to use the car and garage models from the Sample Chain Reaction Device Assembly Instructions. You may choose to use a different car and/or garage design, or even have students build these creatively if desired and time allows. You have the option of asking students to use and modify the Chain Reaction Device previously built for the **Chain Reaction Challenge** in the earlier unit by adding "only" additional motors, sensors, and programming; or you may ask students to design, build, and program from scratch in this challenge.

1 Hour:

Challenge planning using Idea Book Pages (J.4) from this unit. Have students plan and design an autonomous Chain Reaction Device that meets challenge and rubric criteria.

3+ Hours:

Student teams design, build, program, and test Chain Reaction Devices for the given challenge while using the "THINK-DO-TEST" approach to complete the troubleshooting Idea Book pages. Use the corresponding Rubric as a vehicle for improvement during the process and/or to assess final designs. You may also ask students to show, present, or "hand in" copies of their programming work for evaluation.

30+ Minutes:

Have students demonstrate their final/functional Chain Reaction Devices for whole class.

- Celebrate effort and results
- Optionally, create & give awards in addition to providing rubric, Idea Book Page, and programming feedback.

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
4	Energy	4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.	- Device Build(s) - Idea Book Pages
4	Energy	4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	- Device Build(s) - Idea Book Pages
3-5	Engineering Design	3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	- Device Build(s) - Idea Book Pages - Following Challenge Rules
3-5	Engineering Design	3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	- Device Build(s) - Programming - Idea Book Pages - Following Challenge Rules
3-5	Engineering Design	3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	- Device Build(s) - Idea Book Pages - Following Challenge Rules
6-8	Energy	MS-PS3-5	Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.	- Device Build(s) - Idea Book Pages
6-8	Engineering Design	MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	- Device Build(s) - Programming - Idea Book Pages
6-8	Engineering Design	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.	- Device Build(s) - Idea Book Pages
6-8	Engineering Design	MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	- Device Build(s) - Programming - Idea Book Pages

J.t3 cont.

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	- Device Build(s) - Programming - Idea Book Pages
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	- Device Build(s) - Programming - Idea Book Pages
1.G	6-8	Students will develop an understanding of the characteristics and scope of technology.	The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.	- Device Build(s) - Programming - Idea Book Pages
2.G	3-5	Students will develop an understanding of the characteristics and scope of technology.	When parts of a system are missing, it may not work as planned.	- Device Build(s) - Programming - Idea Book Pages
2.L	3-5	Students will develop an understanding of the characteristics and scope of technology.	Requirements are the limits to designing or making a product or system.	- Device Build(s) - Programming - Idea Book Pages
2.Q	6-8	Students will develop an understanding of the characteristics and scope of technology.	Malfunctions of any part of a system may affect the function and quality of the system.	- Device Build(s) - Programming - Idea Book Pages
2.R	6-8	Students will develop an understanding of the characteristics and scope of technology.	Requirements are the parameters placed on the development of a product or system.	- Following Challenge Rules
2.U	6-8	Students will develop an understanding of the characteristics and scope of technology.	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.	- Device Build(s) - Idea Book Pages
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	- Device Build(s) - Programming - Idea Book Pages
8.D	3-5	Students will develop an understanding of the attributes of design.	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.	- Following Challenge Rules
8.F	6-8	Students will develop an understanding of the attributes of design.	There is no perfect design.	- Device Build(s) - Idea Book Pages - Following Challenge Rules
8.G	6-8	Students will develop an understanding of the attributes of design.	Requirements for a design are made up of criteria and constraints.	- Following Challenge Rules

J.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
9.C	3-5	Students will develop an understanding of engineering design.	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.	- Device Build(s) - Programming - Idea Book Pages - Following Challenge Rules
9.D	3-5	Students will develop an understanding of engineering design.	When designing an object, it is important to be creative and consider all ideas.	- Device Build(s) - Programming - Idea Book Pages
9.F	6-8	Students will develop an understanding of engineering design.	Design involves a set of steps, which can be performed in different sequences and repeated as needed.	- Device Build(s) - Programming - Idea Book Pages
9.G	6-8	Students will develop an understanding of engineering design.	Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.	- Idea Book Pages
10.C	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a way of finding out why something does not work so that it can be fixed.	- Device Build(s) - Idea Book Pages
10.D	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention and innovation are creative ways to turn ideas into real things.	- Device Build(s) - Programming - Idea Book Pages
10.E	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	The process of experimentation, which is common in science, can also be used to solve technological problems.	- Device Build(s) - Programming - Idea Book Pages
10.F	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.	- Device Build(s) - Programming - Idea Book Pages
10.G	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.	- Device Build(s) - Programming - Idea Book Pages

J.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
10.H	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Some technological problems are best solved through experimentation.	- Device Build(s) - Programming - Idea Book Pages
11.F	3-5	Students will develop abilities to apply the design process.	Test and evaluate the solutions for the design problem.	- Device Build(s) - Programming - Idea Book Pages
11.G	3-5	Students will develop abilities to apply the design process.	Improve the design solutions.	- Device Build(s) - Programming - Idea Book Pages
11.H	6-8	Students will develop abilities to apply the design process.	Apply a design process to solve problems in and beyond the laboratory-classroom.	- Device Build(s) - Programming - Idea Book Pages
11.K	6-8	Students will develop abilities to apply the design process.	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	- Device Build(s) - Programming - Idea Book Pages

Common Core Standards for Mathematics (CCSM)

Domain #	Grade	Cluster	Standard	Unit Activities
4.OA	4	Operations and Algebraic Thinking	Use the four operations with whole numbers to solve problems.	- Idea Book Pages
4.MD	4	Measurement and Data	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	- Idea Book Pages
4.MD	4	Measurement and Data	Represent and interpret data.	- Idea Book Pages
6.EE	6	Expressions and Equations	Represent and analyze quantitative relationships between dependent and independent variables.	- Idea Book Pages
7.RP	7	Ratios and Proportional Relationships	Analyze proportional relationships and use them to solve real-world and mathematical problems.	- Idea Book Pages



Note: Given the nature of an open-ended challenge like the one in this unit of study, it's not feasible to list all possible standards connections. The standards listed above are only samples and a fraction of what can be accomplished with this unit. We encourage educators to delve deeper into the areas of STEM most meaningful and useful to their students, tailoring Idea Book entries and/or adding their own lessons where they'd like.

Areas to find/develop additional standards connections for this unit:

NGSS: Structure and Properties of Matter, Energy, Engineering Design, Forces and Interactions

STL: The Nature of Technology, Design, Abilities for a Technological World, The Designed World

CCSM: Operations and Algebraic Thinking, Number and Operations – Fractions, Measurement and Data, Geometry, Ratios and Proportional Relationships, Expressions and Equations, Statistics and Probability.

J.t4

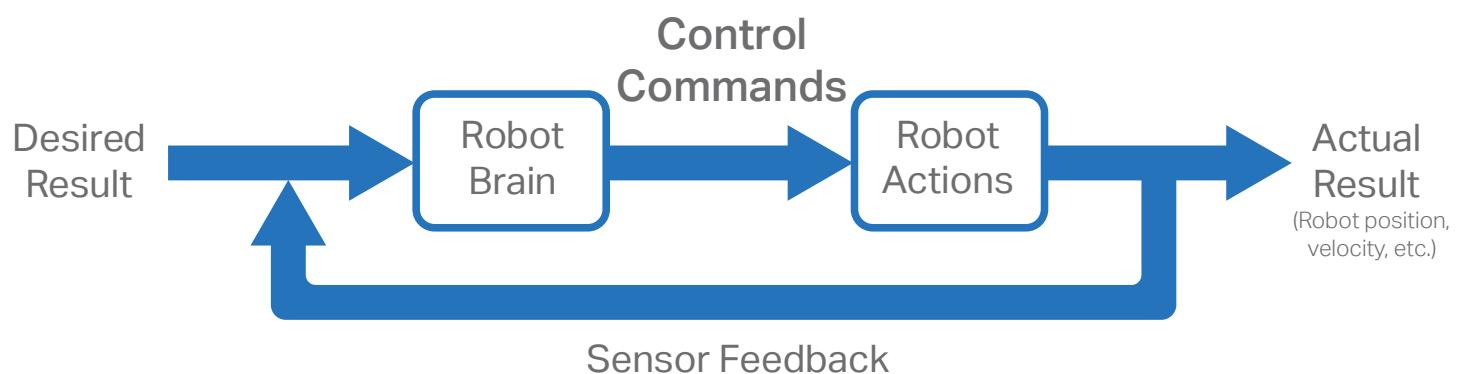
Unit Notes

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Smarter Machines

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 4 to Grade 8

Suggested Prior Learning:

- Completion of the Let's Get Started, Your First Robot, and Smart Machines units are suggested.
- Additionally, familiarity with your chosen VEX IQ programming software is essential.

Unit Purpose:

The purpose of this unit is for students to increase proficiency with VEX IQ Sensors and increase robot programming capabilities.

Learning Objectives:

- Students will learn more key terminology related to sensors and programming
- Students will review sensor types and capabilities
- Students will utilize design process through build/programming challenges
- Students will document program design in their Idea Book pages
- Students will be able to troubleshoot and solve problems to improve their design

Unit Vocabulary:

Control

Closed-Loop Control System

Open-Loop Control System

Unit Materials:

- Unit Content Material (K.1, K.2, K.3, K.4)
- Unit Written Exercise (K.7)
- Unit Rubric (K.6)
- Unit Application Exercise (K.5)
- Pencils or pens
- VEX IQ Robot Brain, Controller, Sensors, kit hardware, and programming software
- Red, Green, and/or Blue objects as called for in Challenges
- Internet access for website use – optional
- Additional paper – optional

Unit Plan and Options

30 Minutes – 3 Hours: Possible Robot Builds for Programming Challenges

Time will vary greatly depending on the need for partial or full builds of any of the following robots.



Clawbot IQ with Sensors
Separate Assembly Instructions



Armbot IQ
Separate Assembly Instructions



Your Own Creation
Teacher-created challenge

1 Hour – 4 Hours Each: Possible Programming Challenges

Time will vary based on difficulty of task, detail of documentation expected on Idea Book pages, and number of iterations needed for students to succeed.

Possible Clawbot IQ with Sensors Challenges:

1. Program the robot AUTONOMOUSLY as follows (no Controller):
 - The robot claw should start by holding an object like a cube, ball, or plastic cup in the claw
 - The program should start running autonomously with a tap of the Touch LED
 - The robot should turn 360 degrees using the Gyro and Smart Motors or just the Smart Motors
 - Have the robot arm lift up, then open its claw and drop the object
 - Have the Robot Brain display, "I AM DONE" and the Touch LED glow Red at conclusion of the program
2. Program the robot for the following HYBRID functions (Robot is controlled with Controller):
 - Program the robot arm joint to stop turning in the downward direction when the arm presses the Bumper Switch. Each time the arm is lifted and dropped, the Bumper Switch should protect a robot driver from dropping the arm too far.
 - Program the color sensor to recognize an object's color when holding it and print that color name on the Robot Brain LCD screen when the object is being held. The object should be red, blue, or green and easy to manipulate (cube, ball, or plastic cup for example)
 - Program the Distance Sensor to stop the robot 100 mm away from a wall or obstacle, preventing a driver from hitting that obstacle.

*Test these functions out one at a time or all together using your controller.

3. Teacher Created Challenge

K.t2 cont.

Possible Armbot IQ Challenges:

1. Program the robot AUTONOMOUSLY as follows (no Controller):

- Item delivery. Program the robot to pick up items (cubes, balls, etc) from a specific location and deliver them to a second specific location, one at a time.

 Note: objects may be placed/and removed one at a time by a teacher or classmate

2. Program the robot AUTONOMOUSLY as follows (no Controller):

- Color sorter. Program the robot to pick up items (cubes, balls, etc.) that are 2 or 3 different colors (use red, blue, and/or green items), one at a time, from a specific location and deliver them to color specific destinations (one destination for red, another for blue, a third for green).

 Note: objects may be placed/and removed one at a time by a teacher or classmate

3. Teacher Created Challenge

Possible Challenges Using a Custom Created VEX IQ Robot:

1. Create & Program a VEX IQ robot that successfully navigates a maze autonomously using sensors
2. Create & Program a VEX IQ robot that successfully delivers an object to an exact location autonomously using sensors
3. Teacher Created Challenge

K.t3

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
4	Energy	4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	<ul style="list-style-type: none">- Challenge Build/ Programming- Idea Book Pages
3-5	Engineering Design	3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	<ul style="list-style-type: none">- Challenge Build/ Programming- Idea Book Pages- Following Challenge Criteria
3-5	Engineering Design	3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	<ul style="list-style-type: none">- Challenge Build/ Programming- Idea Book Pages- Following Challenge Criteria
3-5	Engineering Design	3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	<ul style="list-style-type: none">- Challenge Build/ Programming- Idea Book Pages- Following Challenge Criteria
6.8	Engineering Design	MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	<ul style="list-style-type: none">- Challenge Build/ Programming- Idea Book Pages- Following Challenge Criteria

K.t3 cont.

Next Generation Science Standards (NGSS) - Continued

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
6.8	Engineering Design	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.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
6.8	Engineering Design	MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
1.G	6-8	Students will develop an understanding of the characteristics and scope of technology.	The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
2.G	3-5	Students will develop an understanding of the core concepts of technology.	When parts of a system are missing, it may not work as planned.	<ul style="list-style-type: none"> - Challenge Build/ Programming
2.L	3-5	Students will develop an understanding of the core concepts of technology.	Requirements are the limits to designing or making a product or system.	<ul style="list-style-type: none"> - Following Challenge Criteria
2.Q	6-8	Students will develop an understanding of the core concepts of technology.	Malfunctions of any part of a system may affect the function and quality of the system.	<ul style="list-style-type: none"> - Challenge Build/ Programming
2.R	6-8	Students will develop an understanding of the core concepts of technology.	Requirements are the parameters placed on the development of a product or system.	<ul style="list-style-type: none"> - Following Challenge Criteria
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria

K.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
8.D	3-5	Students will develop an understanding of the attributes of design.	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design	- Following Challenge Criteria
8.F	6-8	Students will develop an understanding of the attributes of design.	There is no perfect design.	- Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
8.G	6-8	Students will develop an understanding of the attributes of design.	Requirements for a design are made up of criteria and constraints.	- Following Challenge Criteria
9.C	3-5	Students will develop an understanding of engineering design.	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.	- Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
9.D	3-5	Students will develop an understanding of engineering design.	When designing an object, it is important to be creative and consider all ideas.	- Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
9.F	6-8	Students will develop an understanding of engineering design.	Design involves a set of steps, which can be performed in different sequences and repeated as needed.	- Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
9.G	6-8	Students will develop an understanding of engineering design.	Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.	- Idea Book Pages
10.C	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a way of finding out why something does not work so that it can be fixed.	- Challenge Robot Build - Programming Activities - Idea book Pages
10.D	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention and innovation are creative ways to turn ideas into real things.	- Challenge Build/ Programming - Idea Book Pages/ Engineering Notebook

K.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
10.E	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	The process of experimentation, which is common in science, can also be used to solve technological problems.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
10.F	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
10.G	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
10.H	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Some technological problems are best solved through experimentation.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
11.F	3-5	Students will develop abilities to apply the design process	Test and evaluate the solutions for the design problem.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
11.G	3-5	Students will develop abilities to apply the design process	Improve the design solutions.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
11.H	6-8	Students will develop abilities to apply the design process	Apply a design process to solve problems in and beyond the laboratory-classroom.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria
11.K	6-8	Students will develop abilities to apply the design process	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	<ul style="list-style-type: none"> - Challenge Build/ Programming - Idea Book Pages - Following Challenge Criteria

K.t3 cont.

Common Core Standards for Mathematics (CCSM)

Domain #	Grade	Cluster	Standard	Unit Activities
4.OA	4	Operations and Algebraic Thinking	Use the four operations with whole numbers to solve problems.	- Idea Book Pages
4.MD	4	Measurement and Data	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	- Idea Book Pages
4.MD	4	Measurement and Data	Represent and interpret data.	- Idea Book Pages
6.EE	6	Expressions and Equations	Represent and analyze quantitative relationships between dependent and independent variables.	- Idea Book Pages
7.RP	7	Ratios and Proportional Relationships	Analyze proportional relationships and use them to solve real-world and mathematical problems.	- Idea Book Pages

Unit Notes

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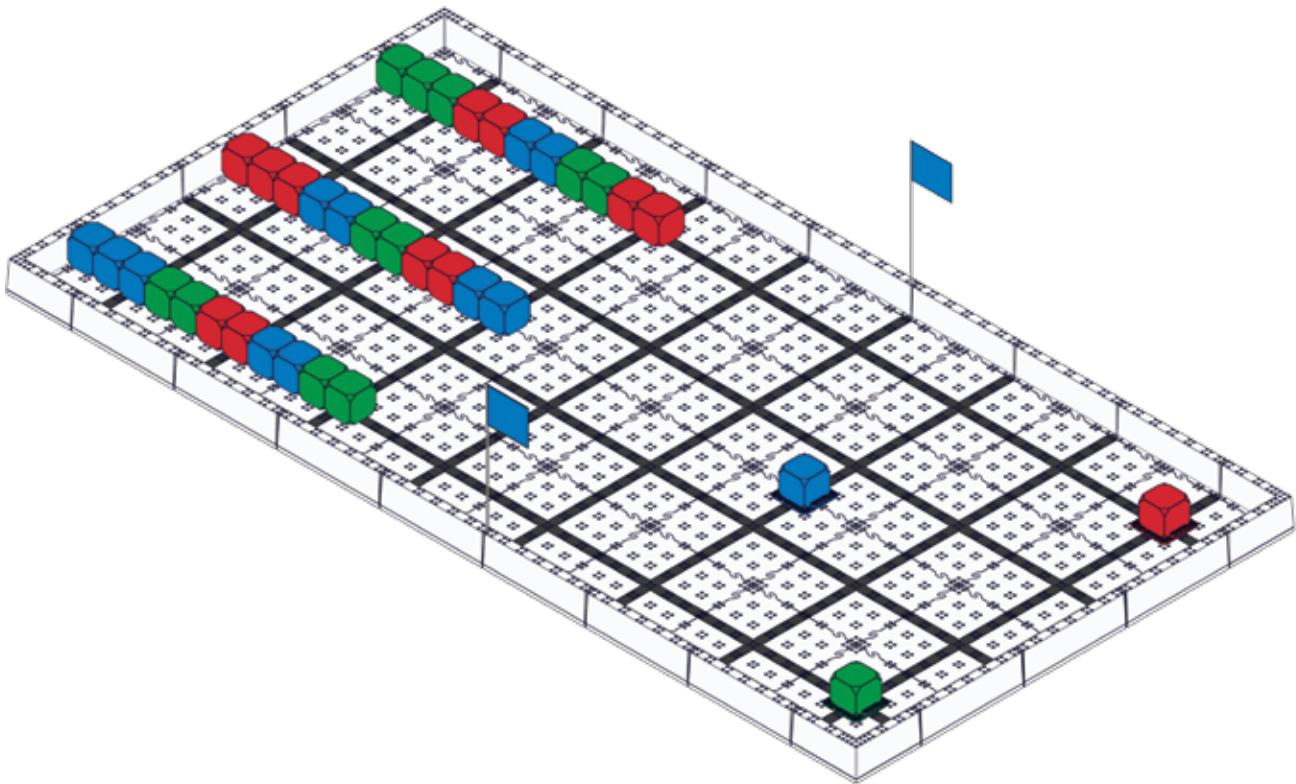
K.t4 cont.

Unit Notes



Highrise Programming Challenge

Teacher Unit Materials



Unit Purpose, Objectives, Vocabulary, & Materials

Recommended Grade Level:

Grade 4 to Grade 8

Suggested Prior Learning:

- For Mechanical Robot Build, completion of the **Let's Get Started & Your First Robot** units are suggested
- Additionally, completion of the **Key Concepts & Mechanisms** units would be very helpful
AND/OR
- Completion of the **Highrise Challenge** unit



Note: If this unit and robot are complete, students only need to add sensors and programming to their existing robot.

For Sensor Use and Programming

- Completion of the **Smart Machines & Smarter Machines** units are suggested
- Additionally, completion of the **Chain Reaction Programming Challenge** unit would be very helpful

Unit Purpose:

The purpose of this unit is for students to design and build a challenge-ready autonomous robot for the Highrise Challenge (or similar autonomous challenge designed by the teacher).

Learning Objectives:

- Students will utilize design process
- Students will document design
- Students will be able to troubleshoot and solve problems to improve design
- Students will participate in the Highrise (or similar) Challenge

Additional Purpose(s)/Objectives:

If desired, teachers can add additional content-specific purposes and objectives to any open-ended robotics challenge (like this unit provides) to develop corresponding targeted lessons around specific science, technology, and math content.

Unit Vocabulary:

Engineering Notebook

Control System

Electrical System

Mechanical System

Sensor

L.t1 cont.

Unit Materials:

-  Unit Content Material (L.1, L.2, L.3)
-  Unit Rubric (L.4)
-  Unit Written Exercise (L.5)
- Challenge rules and game documentation
- Pencils or pens
- VEX IQ Robot Brain, Controller, sensors, kit hardware, programming software
- Highrise Field & Game Elements (or equivalent for alternate game challenge)
- VEX IQ Challenge Full Field Perimeter & Tiles (or equivalent)
- Internet access for website use – optional
- Additional paper – optional

L.t2

Unit Plan and Options:

 Note: If students already have a completed teleoperated robot from the Highrise Challenge unit, then students can add sensors and programming to those existing robots and you can adjust plans below accordingly.

20 Minutes:

Introduce Game and Field to students. Provide copies of rules and corresponding documentation.

30 Minutes:

Lead a brainstorming activity with student teams (large group or small) to generate ideas on how to best play the game (strategy) and what kind of robot can achieve a set of desired goals. Use Idea Book pages or Engineering Notebook during this process.

30 Minutes:

From the brainstorming lists, student teams choose their desired strategy and sketch/describe what that robot might look like on their Idea Book page or in their Engineering Notebook.

5+ Hours:

Over several days/weeks, student teams design, build, program, and test their autonomous robot for the given challenge. Teams will utilize the "THINK-DO-TEST" approach to completing the Idea Book Pages or Engineering Notebook entries while building within the constraints of the challenge rules. Use the Robot Challenge Evaluation Rubric as a vehicle for improvement during the process and/or to assess final programs and designs. Idea Book pages / Engineering Notebooks are part of the rubric, but can also be assessed for a grade separately if desired.

2+ Hours:

Have students compete in the challenge within the classroom OR attend/hold an official VEX IQ Challenge event (see www.robotevents.com for details).

Ideas for a fun, exciting classroom event:

- Announce matches
- Use AV displays for scores, pictures, and more
- Invite your principal, parents, and/or STEM-connected adults from the community
- Provide awards in several categories just like official events (on field scores, design, teamwork, and more)
- Invite outside adults/school officials to be referees or judges and interview students about their designs, programs, and process
- Celebrate effort and results

Unit Standards Connections:

Next Generation Science Standards (NGSS)

Grade	Category	PE Code	Performance Expectation (PE)	Unit Activities
4	Energy	4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
4	Energy	4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
3-5	Engineering Design	3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
3-5	Engineering Design	3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
3-5	Engineering Design	3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
6-8	Energy	MS-PS3-5	Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
6-8	Engineering Design	MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
6-8	Engineering Design	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.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
6-8	Engineering Design	MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook

L.t3 cont.

Standards for Technological Literacy (STL)

Code	Grade	Standard	Benchmark	Unit Activities
1.D	3-5	Students will develop an understanding of the characteristics and scope of technology.	Tools, materials, and skills are used to make things and carry out tasks.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
1.F	6-8	Students will develop an understanding of the characteristics and scope of technology.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
1.G	6-8	Students will develop an understanding of the characteristics and scope of technology.	The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
2.G	3-5	Students will develop an understanding of the core concepts of technology.	When parts of a system are missing, it may not work as planned.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
2.L	3-5	Students will develop an understanding of the core concepts of technology.	Requirements are the limits to designing or making a product or system.	- Challenge Robot Build - Idea Book Pages/ Engineering Notebook
2.Q	6-8	Students will develop an understanding of the core concepts of technology.	Malfunctions of any part of a system may affect the function and quality of the system.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
2.R	6-8	Students will develop an understanding of the core concepts of technology.	Requirements are the parameters placed on the development of a product or system.	- Following Challenge Rules
2.U	6-8	Students will develop an understanding of the core concepts of technology.	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
8.C	3-5	Students will develop an understanding of the attributes of design.	The design process is a purposeful method of planning practical solutions to problems.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
8.D	3-5	Students will develop an understanding of the attributes of design.	Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.	- Following Challenge Rules
8.F	6-8	Students will develop an understanding of the attributes of design	There is no perfect design.	- Challenge Robot Build - Programming Activities - Idea Book Pages/Eng Notebook - Following Challenge Rules
8.G	6-8	Students will develop an understanding of the attributes of design	Requirements for a design are made up of criteria and constraints.	- Following Challenge Rules

L.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
9.C	3-5	Students will develop an understanding of engineering design.	The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook - Following Challenge Rules
9.D	3-5	Students will develop an understanding of engineering design.	When designing an object, it is important to be creative and consider all ideas.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
9.F	6-8	Students will develop an understanding of engineering design.	Design involves a set of steps, which can be performed in different sequences and repeated as needed.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
9.G	6-8	Students will develop an understanding of engineering design.	Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.	- Idea Book Pages/ Engineering Notebook
10.C	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a way of finding out why something does not work so that it can be fixed.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
10.D	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention and innovation are creative ways to turn ideas into real things.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
10.E	3-5	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	The process of experimentation, which is common in science, can also be used to solve technological problems.	- Challenge Robot Build - Programming Activities - Idea Book Pages/ Engineering Notebook
10.F	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.	- Challenge Robot Build - Programming Activities - Idea Book Pages/Eng Notebook
10.G	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.	- Challenge Robot Build - Programming Activities - Idea Book Pages/Eng Notebook

L.t3 cont.

Standards for Technological Literacy (STL) - Continued

Code	Grade	Standard	Benchmark	Unit Activities
10.H	6-8	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	Some technological problems are best solved through experimentation.	- Challenge Robot Build - Programming Activities - Idea Book Pages/Eng Notebook
11.F	3-5	Students will develop abilities to apply the design process.	Test and evaluate the solutions for the design problem.	- Challenge Robot Build - Programming Activities - Idea Book Pages/Eng Notebook
11.G	3-5	Students will develop abilities to apply the design process.	Improve the design solutions.	- Challenge Robot Build - Programming Activities - Idea Book Pages/Eng Notebook
11.H	6-8	Students will develop abilities to apply the design process.	Apply a design process to solve problems in and beyond the laboratory-classroom.	- Challenge Robot Build - Programming Activities - Idea Book Pages/Eng Notebook
11.K	6-8	Students will develop abilities to apply the design process.	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.	- Challenge Robot Build - Programming Activities - Idea Book Pages/Eng Notebook

Common Core Standards for Mathematics (CCSM)

Domain #	Grade	Cluster	Standard	Unit Activities
4.OA	4	Operations and Algebraic Thinking	Use the four operations with whole numbers to solve problems.	- Idea Book Pages/ Engineering Notebook
4.MD	4	Measurement and Data	Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.	- Idea Book Pages/ Engineering Notebook
4.MD	4	Measurement and Data	Represent and interpret data.	- Idea Book Pages/ Engineering Notebook
6.EE	6	Expressions and Equations	Represent and analyze quantitative relationships between dependent and independent variables.	- Idea Book Pages/ Engineering Notebook
7.RP	7	Ratios and Proportional Relationships	Analyze proportional relationships and use them to solve real-world and mathematical problems.	- Idea Book Pages/ Engineering Notebook



NOTE: Given the nature of an open-ended robotics challenge like the one in this unit of study, it's not feasible to list all possible standards connections. The standards listed above are only samples and a fraction of what can be accomplished with this unit. We encourage educators to delve deeper into the leg(s) of STEM most meaningful and useful to their students, tailoring Idea Book/Engineering Notebook entries and/or adding their own lessons where they'd like.

Areas to find/develop additional standards connections for this unit:

NGSS: Structure and Properties of Matter, Energy, Engineering Design, Forces and Interactions

STL: The Nature of Technology, Design, Abilities for a Technological World, The Designed World

CCSM: Operations and Algebraic Thinking, Number and Operations – Fractions, Measurement and Data, Geometry, Ratios and Proportional Relationships, Expressions and Equations, Statistics and Probability

Unit Notes

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L.t4 cont.

Unit Notes

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Robotics Education Guide Teacher Supplement

Ages 8+

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