POMPTON LAKES SCHOOL DISTRICT

Robotics and Product Design

COURSE OF STUDY

September 2017

Submitted by
The Mathematics Department

Unit Overview

Content Area: Engineering Technology

Unit Title: Unit 1 – Introduction to Engineering and Robotics

Target Course/Grade Level: Robotics and Product Design/11 and 12

Unit Summary

In this unit, students will learn about what engineering is and what engineers do with emphasis in the field of robotics. Students will learn about the role of robotics in society and how they are used in all aspects of STEM education.

STEM Connections

The major engineering concepts include classical mechanics, computer-aided design, prototyping, manufacturing and iteration will be introduced as well as discussed. The concepts of how robots have been developed to work in industry, and in research both in autonomous and tele-operated control will be featured. The relationship between different subsystems and how they come together to produce a functioning robot that will be able to complete a task will be introduced.

Student Learning Objectives

Students will be able to:

1. Demonstrate how classical mechanics is used in the engineering process.
2. Correctly produce entries into their engineering notebook.
3. Produce a prototype of their design.
4. Discuss how robots are used today in industry, research and education.
5. Explain what the different basic components of a robot are and how they perform their function.
6. Assemble the VEX Clawbot using provided directions.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

All of the content presented in this course has connections to the standards for mathematical practices.

NGSS #	Next Generation Science Standards
HS-ETS 1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.

Unit Essential Questions

- What is engineering?
- How do robots make our lives better?
- What are the job opportunities for engineers and robotic technicians in the future?

Unit Enduring Understandings

- Robots can be designed to perform tasks that would be difficult, dangerous, or impossible for humans to do.
- Engineering is the application of practical and scientific knowledge to the solving of a problem through the use of a methodical process.

Key Terminology
Engineering, methodical, classical mechanics, structural design, innovation, quantitative, specifications, prototype, assembly drawings, bill of materials, manufacturing plans, robotics, subsystem, manipulators, control system, central processing unit, drivetrain, actuators, servo, gyroscope, light sensor, optical encoder and autonomous.

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1.) What is something that you have used today that was designed by an engineer?
2.) Why is classical mechanics such an important part of engineering?
3.) Why is making a prototype so important to the design process?
4.) How do robots benefit society?
5.) How does the installation of sensors improve the functioning of a robot?

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 Introduction to Engineering and Design Teams	2 days
Lesson 2 Engineering Design Process Steps	3 days
Lesson 3 Construction of Basic Robot	5 days

Materials Needed:
Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview	
Content Area:	Engineering Technology
Unit Title:	Unit 2 – Introduction to VEXnet
Target Course/Grade Level:	Robotics and Product Design/11 and 12

Unit Summary

In this unit, students will learn what the core components and function of the VEX control system are – the Cortex Microcontroller, VEXnet joystick and VEXnet wireless link

STEM Connections

The concept of how the VEX Cortex Microcontroller coordinates the flow of all information and power on the robot is addressed. The demonstration of how the flow of electronic information is handled between the system components and the interface is featured. The concept that a robot is a very complex system of parts that must work together in order to achieve a desired goal is brought to the forefront. The electronic controls provided by a programmable controller demonstrates that a robot is coordinate of operation of different components to achieve its goal.

Student Learning Objectives

Students will be able to:

1. Explain what the specific components that make up the VEXnet system can do and how they are used to control the robot.
2. Set up the microcontroller to function in both autonomous and drive-controlled modes.
3. Use the VEXnet system to successfully control their robot in a classroom challenge.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

All of the content presented in this course has connections to the standards for mathematical practices.

NGSS #	Next Generation Science Standards
HS-ETS 1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.

Unit Essential Questions

- Why are robots designed to operate autonomously?
- Why is the microprocessor considered the brain of a robot?
- Why is it important to maintain a detailed engineering notebook when solving engineering challenges?

Unit Enduring Understandings

- A robot is a very complex system of parts that must work together in order to achieve a desired goal.
- Computer Science and coding are vital to the operation of a robot?

Key Terminology

Microcontroller, bi-directional communication, debugging, downloading, interface, autonomously, and jumpers.

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1.) Explain how the microprocessor functions.
2.) Explain how the VEXnet works.
3.) Explain how you were able to use the joysticks in conjunction with the VEXnet system to pick up and score the bottles in your classroom challenge.
4.) Explain how you can improve your score in the classroom challenge using the control system of the robot.

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans	
Lesson	**Timeframe**
Lesson 1 Terminology Explanation	1 day
Lesson 2 Configuration of VEXnet with Robots	2 days
Lesson 3 Introduction/Prepare for Competition	1 day
Lesson 4 Competition	1 day

Materials Needed:
Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor
Empty plastic bottles

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview	
Content Area:	Engineering Technology
Unit Title:	Unit 3 – Introduction to Autodesk Inventor
Target Course/Grade Level:	Robotics and Product Design/11 and 12

Unit Summary

In this unit, students will get an introduction to Autodesk Inventor. They will get an overview of the different ways engineers use Autodesk inventor and then learn specific ways they can use Inventor to help design and build VEX robots.

STEM Connections

Students will be using the software and math formulas to create and animate their 3D VEX models.

Student Learning Objectives

Students will be able to:

1. Create 3D models using Autodesk Inventor.
2. Animate 3D models using Autodesk Inventor.
3. Render 3D models using Autodesk Inventor.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

All of the content presented in this course has connections to the standards for mathematical practices.

NJSLS #	**New Jersey Student Learning Standards**
N-Q-A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N-Q-A.2	Define appropriate quantities for the purpose of descriptive modeling.
N-Q-A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A-CED-A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.*
A-REI-A.2	Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise
A-REI-B.3	Solve linear equations and inequalities in one variable, including equations with co-efficients represented by letters.
NGSS #	**Next Generation Science Standards**
HS-PS4-5	Communicate technical information about how some technical devices use principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Unit Essential Questions	**Unit Enduring Understandings**
• How does an engineer utilize computer-aided design software? • Why do manufacturers provide detailed assembly procedures in their packaging? • How does animation and rendering improve an engineer's productivity?	• Computer-Aided Design software enhances the productivity of the engineering design process. • Utilizing a materials list and following well-designed procedures is vital to the assembly process.

Key Terminology
Computer-Aided Design, assemblies, animate, rendering, constraints, degrees of freedom, bottom-up modeling, top-down modeling, and views.

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1.) Which items in the classroom require 3D modeling software in order to be designed and manufactured?
2.) Which type of engineers use CAD and how do they use it for their day-to-day job?
3.) Why do designers create virtual models?
4.) What is the benefit to designers of being able to animate an assembly?
5.) What would a designer use a rendered image of a design for?

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 Introduction to Computer-Aided Design	1 day
Lesson 2 Basics of Autodesk Inventor	1 day
Lesson 3 Creation of Robot with Autodesk Inventor	5 days

Materials Needed:
Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor
Autodesk Inventor Video Series

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview	
Content Area:	Engineering Technology
Unit Title:	Unit 4 – The Game!
Target Course/Grade Level:	Robotics and Product Design/11 and 12

Unit Summary

In this unit, students will learn the rules of the game, which will be necessary to design robots. The students will be able to analyze potential game strategies. Students will learn the effects of applying a cost benefit analysis to the design process.

STEM Connections

The interconnection of the game analysis, the design process, and the development of prioritizing based on the cost benefit analysis are the hallmarks of integration of STEM topics.

Student Learning Objectives

Students will be able to:

1. Explain how the process of strategic design works.
2. Demonstrate the use of defining objectives to select game objectives.
3. List all the ways to score the most points in the game.
4. Create a cost benefit analysis to demonstrate the strength of different tasks.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

All of the content presented in this course has connections to the standards for mathematical practices.

NJSLS #	New Jersey Student Learning Standards
N-RN.B	Use properties of rational and irrational numbers.
N-Q.A	Reason quantitatively and use units to solve problems.
G-CO.B	Understand congruence in terms of rigid motion.
G-SRT.C	Define trigonometric ratios and solve problems involving right triangles.
G-SRT.D	Apply trigonometry to general triangles.
G-MG.A	Apply geometric concepts in modeling situations.
S-ID.A	Summarize, represent and interpret data on a single count or measurement variable.
NGSS #	**Next Generation Science Standards**
HS-ETS 1-4	Use computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Unit Essential Questions	Unit Enduring Understandings
• Why is it important to prioritize before beginning a challenging task? • How can a cost benefit analysis produce a better result or end product? • Can the concept of strategic design be applied to other disciplines?	• Strategic Design is the process of determining what a robot should be able to do. • A cost benefit analysis is a comparison between the level of task difficulty and the benefit gained from successfully completing the task.

Key Terminology

Strategic design, defining objectives, cost benefit, and prioritization

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1.) How can you maximize the number of points you can score during the game?
2.) How can you keep your opponent from scoring efficiently during the game?
3.) How do you choose what features of the robot are needed to play the game?

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 Strategic Design	1 day
Lesson 2 Cost-Benefit Analysis	1 day
Lesson 3 Prioritization of Tasks	1 day
Lesson 4 Process Flow Chart	2 day

Materials Needed:
Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview		
Content Area:	Engineering Technology	
Unit Title:	Unit: 5 – Object Manipulation	
Target Course/Grade Level:	Robotics and Product Design/11 and 12	
Unit Summary In this unit, students will learn about the different types and categories of robot manipulators. Students will be presented with robot manipulators from the real world, and shown the basic principles behind their operation. Students will then create their own object manipulator for use on their competition robot.		
STEM Connections Students use real world examples of manipulators found in their community.		
Student Learning Objectives		
Students will be able to: 1. Demonstrate the basic concepts of manipulators and accumulators. **2.** Design manipulators and accumulators.		
Mathematical Practices 1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others. 4. Model with mathematics. 5. Use appropriate tools strategically. 6. Attend to precision. 7. Look for and make use of structure. 8. Look for and express regularity in repeated reasoning. *All of the content presented in this course has connections to the standards for mathematical practices.*		
NJSLS #	**New Jersey Student Learning Standards**	
N-Q.A	Reason quantitatively and use units to solve problems.	
A-REI.A	Understand solving equations as a process of reasoning and explain the reasoning.	
S-ID.A	Summarize, represent and interpret data on a single count or measurement variable.	
S-ID.B	Summarize, represent and interpret data on two categorical and quantitative variables.	
S-IC.A	Understand and evaluate random processes underlying statistical experiments.	
S-CP.A	Understand independence and conditional probability and use them to interpret data.	
S-MD.B	Use probability to evaluate outcome of decisions.	
NGSS #	**Next Generation Science Standards**	
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.	
Unit Essential Questions • What are examples of manipulators and accumulators which you observe in everyday life? • Why is it important to create prototypes and experiment with it before one begins production? • How can friction be lessened or increased in a robot or a machine?		**Unit Enduring Understandings** • Manipulators are components that provide the robot with the ability to interact with its environment. Prototypes and experiments are very helpful as designers learn about the nature of an unknown objective.

Key Terminology
Manipulators, plow, scoops, traction, friction, claw, elasticity, accumulators, conveyor, magazine, indexing, hopper, and conveyance.

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1. Why would you choose one type of a manipulator over another type?
2. How can your data from your test improve your redesign?

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 Presentation on Manipulators	2 days
Lesson 2 Presentation on Accumulators	2 days
Lesson 3 Building of Manipulator/Accumulator	3 days

Materials Needed:
Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor
Manipulator and Accumulator Video Series

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview	
Content Area:	Engineering Technology
Unit Title:	Unit 6 – Speed, Power, Torque and DC Motors
Target Course/Grade Level:	Robotics and Product Design/11 and 12
Unit Summary In this unit, students will learn about the physical principles of speed, power and torque. Students will learn about DC motors and how these principles apply to them. Students will apply these concepts on a sample mechanical system to calculate key details of the design.	
STEM Connections The engineering process used in the real world for solving problems using the application of both practical and scientific information which will also follow a methodical process to develop the desired effect.	

Student Learning Objectives

Students will be able to:

1. Explain the difference between speed, power and torque.
2. Demonstrate the concept of speed.
3. Demonstrate the concept of power.
4. Demonstrate the concept of torque.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

All of the content presented in this course has connections to the standards for mathematical practices.

NJSLS #	**New Jersey Student Learning Standards**
N-Q.A	Reason quantitatively and use units to solve problems.
A-REI.A	Understand solving equations as a process of reasoning and explain the reasoning.
N-CN.A	Perform arithmetic operations with complex numbers.
N-RN.B	Use properties of rational and irrational numbers.
C-CO.A	Experiment with transformations in a plane.
G-CO.D	Make geometric constructions.
G-SRT.D	Apply trigonometry to general triangles.
G-GMD.A	Explain volume formulas and use them to solve problems.
G-GMD.B	Visualize relationships between two-dimensional and three-dimensional objects.
S-ID.A	Summarize, represent and interpret data on a single count or measurement variable.
NGSS #	**Next Generation Science Standards**
HS-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS3-3	Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.

Unit Essential Questions	**Unit Enduring Understandings**
1. How is torque and motors related? 2. How is power and work related? **3.** How is rotational speed different and similar to the general concept of speed?	The field of Classical Mechanics deals with the study of bodies in motion, specifically the physical laws that govern bodies under the influence of forces.

Key Terminology

Methodical, engineering, mechanics, speed, rotational speed, acceleration, force, work, power, torque, velocity, actuator, DC motor, voltage, current, stall, and load.

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1. Why would you want to increase your speed and lower your power?
2. Why would you want to increase your power and lower your speed?
3. How does the change in the load affect your current draw?

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 Speed/Acceleration/Force	1 day
Lesson 2 Torque	1 day
Lesson 3 DC Motors	2 days
Lesson 4 Armature Design	2 days
Lesson 5 Armature Creation	3 days
Lesson 6 Armature Testing	1 day

Materials Needed:

Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor
Protractors
Compass
Speed, Power Torque Tutorial Videos

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview	
Content Area:	Engineering Technology
Unit Title:	Unit 7 – Mechanical Power Transmission
Target Course/Grade Level:	Robotics and Product Design/11 and 12
Unit Summary In this unit, students will learn about the different types of mechanical power transmission. Topics include various gear types and how to calculate gear ratios. These principles will then be applied to the types of motors.	
STEM Connections Mathematical concepts will be featured in terms of how a transmission functions.	
Student Learning Objectives	
Students will be able to: 1. Demonstrate how mechanical power transmissions are very important in the design and construction of robots. 2. Vary the gear ratio and the mechanical advantage in a system which gives versatility necessary to accomplish a design goal. **3.** Determine gear inputs and outputs by calculating the difference between them and determine their gear ratio accordingly.	
Mathematical Practices 1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others. 4. Model with mathematics. 5. Use appropriate tools strategically. 6. Attend to precision. 7. Look for and make use of structure. 8. Look for and express regularity in repeated reasoning. *All of the content presented in this course has connections to the standards for mathematical practices.*	
NJSLS #	**New Jersey Student Learning Standards**
N-RN.B	Use properties of rational and irrational numbers.
N-Q.A	Reason quantitatively and use units to solve problems.
A-REI.A	Understand solving equations as a process of reasoning and explain the reasoning.
N-CN.A	Perform arithmetic operations with complex numbers.
C-CO.A	Experiment with transformations in a plane.
G-CO.D	Make geometric constructions.
G-SRT.D	Apply trigonometry to general triangles.
G-GMD.A	Explain volume formulas and use them to solve problems.
G-GMD.B	Visualize relationships between two-dimensional and three-dimensional objects.
S-ID.A	Summarize, represent and interpret data on a single count or measurement variable.
NGSS #	**Next Generation Science Standards**
HS-PS 2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS 3-3	Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.

Unit Essential Questions	Unit Enduring Understandings
• How does mechanical advantage effect the design of power transmission? • What criteria goes into the gear design process? • What mathematical formulas are useful in the gear design process?	• Gear ratios can be used to adjust mechanical advantage so that the motors can do the work more slowly, within their power limit. • Power transmission is simply defined as the transfer of energy from its place of generation or storage to a location where it does work

Key Terminology

Gear, gear ratio, mechanical advantage, transmission, spur gear, bevel gear, crown gear, worm gear, helical gear, idler gear, epicyclical gear, rack and pinion gear, gear pitch, levers and compound gear reduction

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1. How do the different types of gears provide an advantage in a goal design?
2. How do the mathematical calculations help you to determine what type of gear ratio is needed in your design?

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

• Lesson Plans

Lesson	Timeframe
Lesson 1 Transmission Process	1 day
Lesson 2 Power	1 day
Lesson 3 Gears	2 days
Lesson 4 Levers	1 day
Lesson 5 Gear Reduction	2 days
Lesson 6 Motor/Armature/Gear Redesign	3 days

Materials Needed:

Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview	
Content Area:	Engineering Technology
Unit Title:	Unit 8 – Drivetrain Design
Target Course/Grade Level:	Robotics and Product Design/11 and 12
Unit Summary In this unit, students will learn about the principles in friction through the exploration of robot drivetrain design.	
STEM Connections The major physics concepts including friction and traction will be introduced along with the geometry involved in the different types of drivetrains involved in robotics.	
Student Learning Objectives	
Students will be able to: 1. Demonstrate how applied force and friction are related. 2. Distinguish between static and kinetic friction. 3. Calculate wheel speed. 4. Demonstrate how to calculate gear reduction. **5.** Compare and contrast the different types of drivetrains, along with their benefits and drawbacks.	
Mathematical Practices 1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others. 4. Model with mathematics. 5. Use appropriate tools strategically. 6. Attend to precision. 7. Look for and make use of structure. 8. Look for and express regularity in repeated reasoning. *All of the content presented in this course has connections to the standards for mathematical practices.*	
NJSLS #	**New Jersey Student Learning Standards**
N-RN.B	Use properties of rational and irrational numbers.
N-Q.A	Reason quantitatively and use units to solve problems.
A-REI.A	Understand solving equations as a process of reasoning and explain the reasoning.
N-CN.A	Perform arithmetic operations with complex numbers.
C-CO.A	Experiment with transformations in a plane.
G-CO.D	Make geometric constructions.
G-SRT.D	Apply trigonometry to general triangles.
G-GMD.A	Explain volume formulas and use them to solve problems.
G-GMD.B	Visualize relationships between two-dimensional and three-dimensional objects.
S-ID.A	Summarize, represent and interpret data on a single count or measurement variable.
NGSS #	**Next Generation Science Standards**
HS-PS 2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS 3-3	Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.

Unit Essential Questions	**Unit Enduring Understandings**
• How does the coefficient of friction effect the interaction between two surfaces? • How does the ability to work with unit analysis aid one in drivetrain design? • What are the advantages and disadvantages to friction and how can friction be overcome?	• Friction is the force that opposes motion when two surfaces rub together. It is a reaction force only. It occurs when two surfaces are in contact and a force is applied such they slide along one another. • Static Friction is the frictional force between two objects that are NOT moving relative to each other. • Kinetic Friction is the frictional force between two surfaces that ARE moving relative to each other (sliding along each other).

Key Terminology

Friction, traction, drivetrain, static friction, kinetic friction, maximum static friction, magnitude, force of friction, normal force, tractive force, drive wheel, turning point, turning scrub, Ackermann steering, skid steer and Omni directional

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1. How can you use friction to your advantage when you create your robot drivetrain?
2. How can you use geometry to help select the most efficient drivetrain for your robot?

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 Friction/Traction	1 day
Lesson 2 Drivetrains	1 day
Lesson 3 Geometry and Turning of Drivetrain	1 day
Lesson 4 Design of Tuning Drivetrain	1 day
Lesson 5 Motor Loading	1 day
Lesson 6 Drivetrain Design, Testing and Redesign	4 days

Materials Needed:

Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview	
Content Area:	Engineering Technology
Unit Title:	Unit 9 – Lifting Mechanisms
Target Course/Grade Level:	Robotics and Product Design/11 and 12
Unit Summary In this unit, students will learn about the different types of lifting mechanisms and how they work. Engineering topics will include degrees of freedom, shock load, joint loading, joint speed, elevators, linkages and passive resistance.	
STEM Connections The major physics concept of degrees of freedom as well as the mathematical components necessary to calculate the approach of a rotating joint.	
Student Learning Objectives	
Students will be able to: 1. Differentiate the three degrees of freedom. 2. Demonstrate the correct use of the calculations needed to choose a gear reduction. 3. Distinguish between the use of a linkage system and a multi-state elevator in manipulator design. **4.** Explain how passive assistance can improve robot design.	
Mathematical Practices 1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others. 4. Model with mathematics. 5. Use appropriate tools strategically. 6. Attend to precision. 7. Look for and make use of structure. 8. Look for and express regularity in repeated reasoning. *All of the content presented in this course has connections to the standards for mathematical practices.*	
NJSLS #	**New Jersey Student Learning Standards**
N-RN.B	Use properties of rational and irrational numbers.
N-Q.A	Reason quantitatively and use units to solve problems.
A-REI.A	Understand solving equations as a process of reasoning and explain the reasoning.
N-CN.A	Perform arithmetic operations with complex numbers.
C-CO.A	Experiment with transformations in a plane.
G-CO.D	Make geometric constructions.
G-SRT.D	Apply trigonometry to general triangles.
G-GMD.A	Explain volume formulas and use them to solve problems.
G-GMD.B	Visualize relationships between two-dimensional and three-dimensional objects.
S-ID.A	Summarize, represent and interpret data on a single count or measurement variable.
NGSS #	**Next Generation Science Standards**
HS-PS 2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS 3-3	Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.

Unit Essential Questions	**Unit Enduring Understandings**
• How is the concept of degrees of freedom related to the human body? • What are the first three degrees of freedom? • Where are linkages used in everyday life?	• A degree of freedom refers to a something's ability to move in a single independent direction of motion. • Linkages are designed to convert some input motion into a different output motion.

Key Terminology

Object manipulators, lifting mechanisms, degrees of freedom, first, second and third degree of freedom, shock load, joint loading, joint speed, mechanical advantage, factor safety, elevator, actuation, linkages and passive assistance.

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1. Explain how the degrees of freedom will allow you to design a robot that is able to transfer motion as it manipulates objects.
2. Explain how a linkage system allows a robot to complete its objective.
3. Explain how passive assistance can provide a robot with a mechanical advantage.

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 Degrees of Freedom	1 day
Lesson 2 Rotating Joints	1 day
Lesson 3 Elevators	1 day
Lesson 4 Linkages	1 day
Lesson 5 Passive Assistance	1 day
Lesson 6 Design and Creation of Lifting Mechanism	4 days
Lesson 7 Presentation	1 day

Materials Needed:

Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview		
Content Area:	Engineering Technology	
Unit Title:	Unit 10 – Systems Integration	
Target Course/Grade Level:	Robotics and Product Design/11 and 12	
Unit Summary In this unit, the students will learn the techniques that are used in engineering that allow for the successful integration of systems into a cohesive finished product. Students will learn how integration is an integral part of the initial design process.		
STEM Connections A major component of the design process includes the successful integration of all structural systems within the finished product.		
Student Learning Objectives		
Students will be able to: 1. Demonstrate how system integration works. **2.** Demonstrate how they can use the six steps of integration in robot design.		
Mathematical Practices 1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others. 4. Model with mathematics. 5. Use appropriate tools strategically. 6. Attend to precision. 7. Look for and make use of structure. 8. Look for and express regularity in repeated reasoning. *All of the content presented in this course has connections to the standards for mathematical practices.*		

NJSLS #	**New Jersey Student Learning Standards**
N-RN.B	Use properties of rational and irrational numbers.
N-Q.A	Reason quantitatively and use units to solve problems.
A-REI.A	Understand solving equations as a process of reasoning and explain the reasoning.
N-CN.A	Perform arithmetic operations with complex numbers.
C-CO.A	Experiment with transformations in a plane.
G-CO.D	Make geometric constructions.
G-SRT.D	Apply trigonometry to general triangles.
G-GMD.A	Explain volume formulas and use them to solve problems.
G-GMD.B	Visualize relationships between two-dimensional and three-dimensional objects.
S-ID.A	Summarize, represent and interpret data on a single count or measurement variable.
NGSS #	**Next Generation Science Standards**
HS-PS 2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS 3-3	Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.

Unit Essential Questions	**Unit Enduring Understandings**
• Why is it important to consider system integration at the beginning of the design process? • What negatives can arise if system integration is not properly applied?	Systems integration refers to the way that these individual subsystems are combined during the design process into one cohesive product

Key Terminology

System integration, power, control, pneumatics, drivetrain, lifting mechanism, and object manipulators.

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions

1. How does the process of system engineering allow for the development of a well-integrated structure?
2. How does the integration of system engineering early in the design process provide benefits to the overall design?

Formative Assessments

- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 System Integration	1 day
Lesson 2 Completion of Robot Assembly	4 days

Materials Needed:

Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor

Curriculum Development Resources

http://vexrobotics.com/curriculum

Unit Overview	
Content Area:	Engineering Technology
Unit Title:	Unit 11 – Product Design and Testing
Target Course/Grade Level:	Robotics and Product Design/11 and 12

Unit Summary

Engineers and designers use a variety of tools and techniques, ranging from freehand pencil sketches to sophisticated digital modeling, to explore ideas and communicate concepts and technical directions to others. The design development process can be expedited through the use of virtual prototypes and rapid prototyping. Students will use Autodesk Inventor software to design and model their own custom part for addition onto the robot. The students will then utilize rapid proto-typing (3D Printer) to create their part and implement it onto their robot.

STEM Connections

A key aspect of design innovation involves the ability to analyze existing design solutions to determine areas for improvement. This unit offers students a chance to engage in new product development by exploring ways to develop additional components to enhance or expand the capabilities of a robot.

Student Learning Objectives

Students will be able to:

1. Analyze an existing product to identify potential areas for improvement.
2. Explain how physical stretch models, 2D sketches, and 3D digital models can be used as visualization tools for design ideation.
3. Use Autodesk Inventor to create, render, and animate 3D models.
4. Describe the importance of documenting and annotating a design.
5. Physically create a custom part from a virtual prototype using Autodesk Inventor.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

All of the content presented in this course has connections to the standards for mathematical practices.

NJSLS #	New Jersey Student Learning Standards
N-RN.B	Use properties of rational and irrational numbers.
N-Q.A	Reason quantitatively and use units to solve problems.
A-REI.A	Understand solving equations as a process of reasoning and explain the reasoning.
N-CN.A	Perform arithmetic operations with complex numbers.
C-CO.A	Experiment with transformations in a plane.
G-CO.D	Make geometric constructions.
G-SRT.D	Apply trigonometry to general triangles.
G-GMD.A	Explain volume formulas and use them to solve problems.
G-GMD.B	Visualize relationships between two-dimensional and three-dimensional objects.
S-ID.A	Summarize, represent and interpret data on a single count or measurement variable.
G-C.A	Understand and apply theorems about circles.
NGSS #	**Next Generation Science Standards**
HS-ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impacts.
HS-ETS 1-4	Use computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Unit Essential Questions How can computer-aided design and rapid prototyping improve the delivery times for new product development?	**Unit Enduring Understandings** Once the CAD model has been approved, engineers make physical prototypes of their design using rapid prototyping technologies.

Key Terminology
Computer-aided design, computer numerical control, constraints, design constraints, orthographic view, prototype, rapid prototype, tolerances and 3D printer.

Evidence of Learning

Summative Assessment: Each unit will involve keeping an engineering notebook.

Engineering Notebook Seed Questions
1. What other custom parts could be designed for the robot?
2. How many different methods of rapid prototyping are there?
3. How can model information from Autodesk Inventor be used to produce a real prototype of your design?

Formative Assessments
- Tests and quizzes
- Discussions
- Individual practice
- Explanation of examples
- Daily homework assignments

Lesson Plans

Lesson	Timeframe
Lesson 1 Competition	2 days
Lesson 2 Autodesk Inventor with 3D Printing	2 days
Lesson 3 Design of New Part for Robot with	5 days
Lesson 4 Part Production with 3D Printer	1 day

Materials Needed:
Unit Guide
Paper, Pencils and Rulers
Internet Access
VEX Robotics Kit
Computers with Autodesk Inventor
3D Printer

Curriculum Development Resources

http://vexrobotics.com/curriculum

Content Area Unit Name	English Language Arts, Mathematics, Science, Social Studies, World Language, Practical and Fine Arts, Business
Interdisciplinary Connections	Mathematics, Technology, and English Arts, Science
Core Instructional Materials including digital tools	Textbooks, Classroom Resources, Digital Tools
21st Century Themes and Skills	For information related to the 12 Career Ready Practices follow the links below: http://www.state.nj.us/education/cccs/2014/career/CareerReadyPractices.pdf Personal Financial Literacy 9.1 http://www.state.nj.us/education/cccs/2014/career/91.pdf Career Awareness, Exploration, and Preparation 9.2 http://www.state.nj.us/education/cccs/2014/career/92.pdf Career and Technical Education 9.3 http://www.state.nj.us/education/cccs/2014/career/93.pdf
8.1 Educational Technology **8.2 Technology Education, Engineering, Design, and Computational Thinking - Programming**	K-2: Navigate provided URL'S, Use basic word processing to create and illustrate a simple story, Work collaboratively with peers on project, Use digital tools to explore an issue and design solution for a problem, Identify how technology improves life, Use digital tools to design an approach to solving problems. 3-5: Peers collaborate to produce text about current events; Understand the consequences for inappropriate use of technology and social media, Apply engineering designs to data collection and solutions, Understand how technology evolves based on need and cultural influences. 6-8: Select appropriate technology and applications to create publication on global topic, Use technology and social media responsibly, Employ a wide range of digital resources to collect data and form solutions, Identify the forces that come into play for further development of technology; apply engineering design process to real world problems. 9-12: Create and edit multi-page document for public presentation.

Considerations for classified students:

Classroom Instruction:

- All instruction for classified students will be guided by the students' Individualized Education Plan (IEP).
- Regular education teachers will be responsible for differentiating instruction for classified students based on the instructional modifications listed in the IEP.
- In the case of General Education - Supported Instruction (GE-SI) Classes, the special education teacher will be responsible for support in modifying the curriculum for the students, informing the class room teacher of the modifications, and directing instructional aide(s) to provide support accordingly.
- Grading will be done collaboratively by the regular and special education teachers.

Modifications:

- Modifications include but are not limited to:
  Extra time for assignments, modified classwork/homework assignments based on disability, preferential seating, study guides, copies of class notes, assistive technology and rewording/repeating or clarifying directions.

In-class Assessments:

- All assessments are to be in line with students' IEPs. In-class support teachers should modify tests for classified students. Tests may be given in the regular education classroom or completed with the inclusion teacher in another location with additional time. Students may be tested separately according to the IEP.
- Assessment grades may be modified based on a student's disability and in accordance with their IEP.

Considerations for English Language Learners (ELLs):

Classroom Instruction:

- Instruction for ESL students will be guided by their WIDA English Language Proficiency level. Teachers should receive this level from the ESL teacher assigned to the building.
- General education teachers will be responsible for differentiating instruction for ELLs with the assistance of the ESL teacher that promotes language, literacy and content learning.
- Sheltered Instruction Observation Protocol (SIOP)
  http://siop.pearson.com/about-siop/
  The following 8 components provide all teachers with lesson planning and instructional strategies that support language and learning goals for all students. This approach to teaching aligns with preparing students with college and career ready skills.
  The SIOP Model components:
  1. Lesson Preparation
  2. Building Background
  3. Comprehensible Input
  4. Strategies
  5. Interaction

6. [Practice and Application]
7. [Lesson Delivery]
8. [Review and Assessment]

- In the case of Content-Based ESL (CBE), the ESL teacher and the general education teacher will be responsible for identifying language objectives and additional instructional strategies that improve proficiency in English and academic success of ELLs. Instructional strategies and the necessary scaffolds to promote student learning will be shared with the general education teacher for daily lessons that are aligned to District Curricula, CCSS, and WIDA Standards. The general Education teacher and ESL teacher will be co-teachers for a pre-determined amount of classroom instruction.
- Grading will be done collaboratively by the regular and ESL teachers.

Modifications: The following are possible modifications but are not limited to this list –

- Direct instruction, small group or pullout, about the contrasting letter sound correspondences, syllabication patterns and morphology in English supported with connections to their native language, native language text and/or resources, graphic organizers, visuals, sentence starters/ sentence frames, cloze activities, modeling, working with a partner, timeline and phrase wall and adapted text (in English) or specific sections of the original text, highlighted/bold-faced words within text.
- Draw pictures instead of writing/speaking.
- Match drawings with new vocabulary that might correspond.
- Work in small group or pairs with their English Only (EOs) peers for authentic content language talk and grade level modeling.
- Write simple sentences instead of complex sentences that demonstrates an understanding of academic language particular to specific content.
- Match simple sentences with new vocabulary that might apply to edit sentences.
- Have students provide examples/explanations of main idea in simple sentences. Revisions show an attempt to improve Language Control by embedding academic content vocabulary and Linguistic Complexity by expanding and varying sentence structures and using correct punctuation.
- Draw pictures instead of writing/speaking about seasonal changes. Match drawings with new vocabulary (adjective word wall, content word walls) that might correspond.
- Provide multiple opportunities for authentic speech acts to practice language skills and develop English fluency.
- Total Physical Response (TPR) to model critical thinking skills like analyze and synthesize.
- Study Guides

In Class Assessments:

- All formative and summative assessments will include modifications that support student's English Proficiency level. ESL teachers will collaborate with regular education teachers to provide appropriate differentiation for assessing ELLs.

Considerations for At Risk Students:

- At Risk students are identified by the I&RS committee in each school. The committee works to understand the reasons behind the student's low performance level in school and to create and implement a plan that is carried out by a variety of staff members in the building.
- Teachers with At Risk students are notified by the I&RS committee and provided with a copy of the plan and a timeframe for assessing the growth of the student. There are academic as well as behavioral goals that are listed for the students with recommended strategies unique to each individual.
- Classroom teachers are to follow the plan using instructional strategies that will help the student improve his/her performance while applying appropriate behavioral strategies consistent with the needs of the student.
- Teachers will report student progress to the I&RS committee within the specified timeframe for the plan.

Classroom instruction:

- Teachers will use differentiated instruction for At Risk students as they do for all students in their class. The strategies would be guided by the I&RS plan and be consistent with the student's ability and learning modality.

Modifications:

- Clarify all assignments and place specific timeframes for completion. Provide student with opportunity for one on one time for clarification.
- Set clear expectations for all assignments, in and outside of class. Keep expectations within the framework of the I&RS plan.
- Use positive reinforcement for all successes. Hold student to defined consequences for not completing work.
- Provide time outside the normal class time for completion of work. Not completing assignments is unacceptable, all assignments will be completed.

In Class Assessments:

- At Risk students should receive any modifications listed in their I&RS plan.
- If necessary, students should be provided with extended time to complete assessments.

Considerations for Gifted Students:

- Teachers will use differentiated instruction for Gifted Students as they do for all students in their class.
- Assignments and assessments can be planned and implemented with input from the student.
- Gifted students will be provided with the opportunity to demonstrate their knowledge through a variety of platforms.
- Teachers will have the latitude to provide assignments with the individual student's ability in mind.