THE EDUCATION FUND

FOR EXCELLENCE IN MIAMI-DADE PUBLIC SCHOOLS

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Ideas with IMPACT

idea packet

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Building Robots... and More (SD Robo Tech)

SD ROBO TECH

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Objective:

The students who participate in this program will be able to learn about engineering and robotics concepts that will allow them to design and build a robot to compete in local competitions.

Florida Standards:

Common Career Technical Core – Career Ready Practices

Career Ready Practices describe the career-ready skills that educators should seek to develop in their students. These practices are not exclusive to a Career Pathway, program of study, discipline or level of education. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

1. Act as a responsible and contributing citizen and employee.
2. Apply appropriate academic and technical skills.
3. Attend to personal health and financial well-being.
4. Communicate clearly, effectively and with reason.
5. Consider the environmental, social and economic impacts of decisions.
6. Demonstrate creativity and innovation.
7. Employ valid and reliable research strategies.
8. Utilize critical thinking to make sense of problems and persevere in solving them.
9. Model integrity, ethical leadership and effective management.
10. Plan education and career path aligned to personal goals.
11. Use technology to enhance productivity.
12. Work productively in teams while using cultural/global competence.

Applied Engineering Technology I

Standards

After successfully completing this program, the student will be able to perform the following:

02.0 Demonstrate an understanding of the attributes of design and the engineering design process.

03.0 Describe the functional characteristics of the engineering design team.

04.0 Demonstrate skill in technical sketching and drawing as it relates to engineering design.

05.0 Successfully work as a member of a team.

11.0 Demonstrate knowledge of computer file management.

12.0 Demonstrate proficiency using the Internet to locate information.

14.0 Develop an understanding of computer programming concepts.

15.0 Demonstrate safe and appropriate use of tools.

16.0 Demonstrate an understanding of the various approaches used in problem solving.

17.0 Demonstrate the abilities to apply the design process.

19.0 Apply fundamental computer programming concepts.

20.0 Demonstrate fundamental math and science knowledge and skills for mechanical, fluid, thermal, and/or electrical/electronic systems.

23.0 Demonstrate safe and appropriate use of basic tools and machines.

24.0 Demonstrate the abilities to assess the impact of products and systems.

25.0 Plan, organize, and carry out a project plan.

26.0 Use tools, materials, and processes in an appropriate and safe manner.

27.0 Demonstrate an understanding of design and development of solutions involving mechanical engineering, their environments, and their associated design constraints.

28.0 Design and build a mechanically engineered solution suitable for a particular application in a defined environment.

30.0 Demonstrate an understanding of design and development of solutions involving mechanical engineering, their environments, and their associated design constraints.

31.0 Design and build a mechanically engineered solution suitable for a particular application in a defined environment.

Applied Robotics

<u>Standards</u>

After successfully completing this program, the student will be able to perform the following:

01.0 Demonstrate an understanding of robotics, its history, applications, and evolution.
02.0 Describe programming concepts and the forms of applied logic.
03.0 Describe the role of sensors in the field of robotics.
04.0 Demonstrate an understanding of the foundations of electronics.
05.0 Describe the operation of DC motors and servos used in robotics
06.0 Demonstrate an understanding of engineering design principles.
07.0 Explain fundamental physics concepts applicable to the field of robotics.
08.0 Demonstrate the safe and proper use of electronic and other lab equipment, tools, and materials.
09.0 Build, program, and configure a robot to perform predefined tasks.
10.0 Solve problems using critical thinking skills, creativity and innovation.
11.0 Correlate elements of artificial intelligence to their functions in robotics.
12.0 Describe the various classification schemes of sensors applicable to robotics.
13.0 Explain how electronic devices are used in the operation of a robotic assembly.
14.0 Demonstrate an understanding of various technologies used in the design of robotic assemblies.
15.0 Demonstrate an understanding of advanced mathematics and physics associated with the design of a robotic assembly.
16.0 Create a program to control a robotic mechanism.

17.0 Describe the operation and use of various forms of electrical motors in robotic assemblies.

18.0 Demonstrate an understanding of basic 3D modeling concepts.

19.0 Describe the approaches, challenges, and problem-solving methodologies involved with integrating artificial intelligence into robotic systems.

20.0 Describe the role of specialized sensors in the design and operation of robotic systems.

21.0 Describe the use of specialized electronic applications used in robotic systems.

22.0 Demonstrate the applicability of hybrid systems in robotics.

23.0 Demonstrate an understanding of underlying principles of environmental physics related to robotic technology.

24.0 Demonstrate an understanding of the manufacturing process and its impact on robotics.

25.0 Demonstrate an understanding of topographical and environmental considerations in robotic assembly design.

26.0 Create a program to control a robotic system.

27.0 Demonstrate an understanding of technologies for communication with and among robotic systems.

28.0 Demonstrate an understanding of static and dynamic modeling and simulation concepts related to the design of robotic systems.

29.0 Identify, define, and justify a technical design problem for resolution.

30.0 Conduct research and investigation into the stated problem.

31.0 Design a solution to the problem and create a working prototype for testing.

32.0 Create and deliver a formal presentation in a suitable form of the solution to the problem.

33.0 Perform and graphically represent an evaluation of proposed design solutions using specific criteria, including product specifications.

34.0 Evaluate and select appropriate testing methodologies for testing the product, conduct product testing, refine the design as needed, and document the process and results.

Course Overview:

I would to create an opportunity for low performing students to be exposed to engineering and robotics. Many of my students, are low performing in reading specifically but their interest in technology and robotics is high.

I have a robotics club that meets after school two days a week. I allow students to be exposed to a curriculum that teaches them how to write code and build a VEX Robot. The robots have a specific competition that they can compete in every year and the students must create a robot that can accomplish the task set before them. This past year one of my students earned a 1st place trophy for a team competition at the youth fair with his robot. This young man Antony is a Haitian immigrant who came here after the devastating earthquake years ago. He is so passionate about engineering and robotics he wants to build everything. Before my program he wasn’t sure what path to take after he graduated. However now he has visited both FIU and Miami Dade's Engineering programs and is excited to see if he gains entrance into their programs. He says that being in the club for two years and building those robots to compete has been the highlight of his high school experience. He has even discussed setting up a go fund me account for our club to make sure other students get the same experience. As an educator I am witnessing students become more motivated in school. I have also heard from other teachers that these typically low performing students are doing better in their classes as well.

My idea is to promote success in the areas of Reading, Math, Science, Technology, and Career Readiness by collaborating with other students to build a robot that completes a specific task. We have a group of students here at South Dade Senior High that have both academic and social struggles. Students have real difficulties speaking with unfamiliar groups of people they meet. This is especially true when the students must read and follow instructions to complete a task. In the initial stages of the project students introduce themselves and talk about their experiences with technology and engineering. They are then put into groups to follow a set of instructions to build a specific small beginning robot. As they work together to build the project they are practicing their social skills, their reading comprehension, and their engineering skills without noticing. As time progresses the students begin to get more comfortable working together and even reach out to other groups for advice. In the second year of my club I notice that the group with a years’ experience seeks out the other groups and helps them through their struggles in the designing or coding process.

I plan to have approximately 30 students participate in this activity. Grades will vary from 9th thru 12th grade and ages will range from 14 to 18years old. The club will meet twice a week and allow students with low reading performance levels our lowest 25% to 35% to participate. This program can be adopted to accommodate groups of students with higher or lower achievement by adjusting the amount of instructor and peer support that is given to the groups. I can introduce a student with more experience into a beginning group to facilitate a peer advisor strategy. I can also break off with specific groups and help them achieve a specific task or point them in the direction to research an answer to their problem, and even provide specific instruction for their difficulty.

Having a program like this at our school gives us the chance to offer our community a program they have genuine interest in. Many students are left out because there is nowhere to go to experience these programs. When students have the chance to experience Engineering and Robotics they're eyes are opened to amazing possibilities. Students learn how to improve the world around them by solving problems, and creating solutions. Additionally, they learn how to work together with other like-minded people to accomplish goals. This in turn inspires them to engage in their classes and retain information because they have a goal to achieve, and understand the relevance of education.

Lesson Plans:

Unit 1 Lesson Plan: Introduction to Engineering

Grade Level:
9-12

Prerequisites:

9^{th} grade general math and science

Concepts Addressed:

In this unit, students will learn about what engineering is and what engineers do. The concepts of classical mechanics, design and iteration will be defined and worked through.

Learning Objectives:

- The students will be able to demonstrate how classical mechanics is used in the engineering process.
- The students will be able to correctly produce entries into their engineering notebook.
- The students will be able to produce a prototype of their design.

STEM Connections:

The major engineering concepts including classical mechanics, Design, CAD, Prototyping, manufacturing, and iteration will be featured.

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers
- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources

Key Terminology:

- Engineering
- Methodical

- <u>Classical Mechanics</u>
- <u>Structural Design</u>
- <u>Manufacturing</u>
- <u>Design</u>
- <u>Innovation</u>
- <u>Quantitative</u>
- <u>Specifications</u>
- <u>Ideate</u>
- <u>Prototype</u>
- <u>CAD Models</u>
- <u>Assembly Drawings</u>
- <u>Manufacturing Plans</u>
- <u>Bill of Materials</u>
- <u>Maintenance Guide</u>
- <u>User Manuals</u>
- <u>Design Presentations</u>
- <u>Proposals</u>
- <u>Design Review</u>
- <u>Iterate</u>
- <u>Engineering Notebook</u>

<u>Day to Day Lesson Plan:</u>

Day 1: Open the lesson by having the students construct a list of things in the classroom that have been engineered.

Have the students compare their lists in small groups.
Explain that everything has been engineered and lead into the explanation of what engineering is and what engineers do on a daily basis.
Explain what Design is.

Day 2: Introduce Engineering and Design Teams
Working on a Design Team
Using the Engineering Process [You can go into greater detail of the 11 steps on Day 3.]

Day 3: Begin with Step 1 Understand
Continue through Step 3 Define

Day 4: Begin with Step 4 Ideate
Continue through Step 5
Provide students the opportunity to create a prototype

Day 5: Begin with Step 6
Continue through Step 8 Present

Day 6: Begin with Step 9
Continue through Step 10
Allow students to create an iteration of their design

Day 7: Engineering Notebooks
Introduce the Design Challenge

Day 8: Allow for additional work on the Design Challenge
Allow time for students to document their process.

Day 9: Assessment of vocabulary
Engineering Notebook

Day 10: Review any concepts that were challenging for the students.

Engineering Notebook "Seed Questions":

1. What does an engineer do?
2. What is something that you have used today that was designed by an engineer?
3. Why is classical mechanics such an important part of engineering?
4. How does having constraints placed on a design change the engineering process?
5. Why is making a prototype so important in the design process?
6. What have you learned from the iterative process?

Unit 2 Lesson Plan: Introduction to Robotics

Grade Level:
9-12

Prerequisites:

9th grade general math and science

Concepts Addressed:

In this unit, students will learn about how the field of robotics operates and how robots work. Students will learn about the role of robots in society and how they are used in all aspects of STEM education.

Learning Objectives:

- The students will be able to discuss how robots are used today in industry, research and in education.

- The students will be able to explain what the different basic components of a robot are and how they perform their function.
- The students will be able to correctly produce entries into their engineering notebook.
- The students will be able to assemble the VEX Clawbot using the directions provided in the kit.

STEM Connections:

The concepts of how robots are having been developed to work in industry, and in research both in autonomous and teleoperated control will be featured.
The relationship between the different subsystems and how they come together to produce a functioning robot that will be able to complete a task will be introduced.

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers
- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources

Key Terminology:

- Robot
- Robotics
- Subsystem
- Manipulators
- Control System
- Sensors
- Central Processing Unit (CPU)
- Drivetrain
- Actuators
- Servo
- Ultrasonic Range Finder
- Gyroscope
- Light Sensor
- Optical Encoders
- Microcontroller
- Autonomous

Day to Day Lesson Plan:

Day 1: Begin this unit by finding out what the students know about robots. They can make a list of all the robots that they have encountered or they may sketch what they believe a robot looks like. Introduce the unit beginning with the history of where the term robot comes from. Review the Basic Components of a Robot.

Day 2: Review Uses and Examples of Robots. Students can conduct research on the different NASA missions that have included robotic applications as well as different designs of robots that have been used in law enforcement and industrial applications.

Day 3: Explain why robotics is being used in education and introduce the VEX robotics kit. Review the subsystems that they will need to assemble to complete the construction of the Clawbot. Include a presentation on the hardware that is included in the kit and the use of the Allen keys and open-ended wrenches. Begin Clawbot Construction. Have students take notes on the building process into their Engineering Notebook.

Day 4: Continue Clawbot construction. Remember to charge batteries for testing.

Day 5: Complete the construction of the Clawbot.

Day 6: Have students drive their robots in the classroom using the joysticks.

Day 7: Evaluations

Assessment of vocabulary
Engineering Notebook
Review any concepts that were challenging for the students.

Engineering Notebook "Seed Questions":

1. How do robots benefit society?
2. Explain how the different subsystems work together.
3. How does the installation of sensors improve the functioning of the robot?

Unit 3 Lesson Plan: Introduction to VEXnet

Grade Level:
9-12

Prerequisites:

9^{th} grade general math and science

Concepts Addressed:

In this unit, students will learn what the core components of the VEX control system are - the Cortex Microcontroller, VEXnet Joystick and VEXnet Wireless link. They will also learn how they each function.

Learning Objectives:

- The students will be able to explain what the specific components that make up the VEXnet System can do and how they are used to control the robot.
- The students will be able to set up their microcontroller to function in both autonomous and drive controlled modes.
- The students will be able to correctly produce entries into their engineering notebook.
- The students will be able to use the VEXnet system to successfully control their robot in a classroom challenge.

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 to achieve a desired goal is brought to the forefront of the presentation. The Electronic controls provided by a programmable controller like the VEX Cortex Microcontroller demonstrates that the robot is coordinate the operation of the different components and achieve its goal.

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers
- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources
- Large container
- Empty plastic bottles or cans

Key Terminology:

- Microcontroller
- Bi-directional communication
- Debugging
- Downloading
- Interface

- <u>Autonomously</u>
- <u>Jumpers</u>

<u>Day to Day Lesson Plan:</u>

Day 1: Begin this unit with an explanation of the terminology used to describe the VEXnet system. Review material on the Cortex Microcontroller and the Joysticks.

Day 2: Continue with information on the VEXnet wireless link and introduce the classroom challenge for this unit.

Day 3: Provide time for the students to wire and configure their robots using the building guide. Allow students to practice for the classroom competition.

Day 4: Classroom competition

Day 5: Student evaluation

Day 6: Review and concepts that need addressing

Engineering Notebooks
Assessment of vocabulary
Engineering Notebook
Review any concepts that were challenging for the students.

Engineering Notebook "Seed Questions":

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

Unit 4 Lesson Plan: Introduction to Autodesk Inventor

Unit 4 Lesson Plan: Introduction to Autodesk Inventor

Grade Level:

9-12

Prerequisites:

9^{th} Grade General Math & Science

Concepts Addressed:

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.

Learning Objectives:

- The students will be able to create 3D models using Autodesk Inventor
- The students will be able to animate 3D models
- The students will be able to render 3D models

STEM Connections:

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

Materials Needed:

- Unit Guide
- Internet Access
- Dictionaries
- VEX Robotics Kit
- Online Resources
- Computer with Autodesk Inventor

Key Terminology:

- Computer Aided Design (CAD)
- Assemblies
- Animate
- Rendering
- Browser Menu
- Constraints
- Degrees of Freedom
- Bottom Up Modeling

- Top Down Modeling
- Views

Day to Day Lesson Plan:

Lesson 1: Introduce the unit with an overview of Computer Aided Design (CAD). Students will familiarize themselves with the basic commands and navigation of Autodesk Inventor. These tutorials are meant as an overview, and the student is not expected to duplicate the work being done in the videos. This first set of videos is also a great refresher if the student has not used the software in a little while. The following videos should be reviewed in Unit 4.2:

1. Primary Environment

2. UI Navigation 1

3. UI Navigation 2

4. Graphics Window Display

5. Navigation Controls

Note - If the student is already familiar with Autodesk Inventor, have them demonstrate the basics and move on to Lesson 3.

Lesson 2: Students will continue to review the basics of Inventor. Encourage students to assist each other in learning the software. They should review the following videos in Unit 4.2:

1. Project Files

2. Creating Assemblies 1

3. Creating Assemblies 2

4. Viewing Assemblies

5. Visualization

Lesson 3: Students will start using Inventor to create the Clawbot model in Unit 4.3. The Overview video will give them an idea of what is expected of them in this project. The files required for this activity must be downloaded, and data sets in Imperial and Metric units are available. Metric equivalents are given throughout the text. Find the files in Unit 4.3, located after Video 1 in the text.

The data sets provided will work for Inventor version 2013 onward. Download and unzip these files and save them into a new project folder called 'Clawbot.'

Students should watch the following videos in Unit 4.3 to learn how to start their CAD project:

- Overview
- Video 1: Review the Robot Model
- Video 2: Start a New Assembly
- Video 3: Complete the Base Frame

Lesson 4: Students should watch the following videos in Unit 4.3 to learn how to virtually assemble the chassis and begin the Clawbot drivetrain:

- Video 4: Add Standard Parts to the Assembly
- Video 5: Assemble Bearing Flats and Rivets
- Video 6: Assemble the Driveshaft and Collar

Lesson 5: Students should watch the following videos in Unit 4.3 to learn how to complete the drivetrain:

- Video 7: Assemble a Wheel
- Video 8: Create a Wheel Subassembly

Lesson 6: Students should watch the following videos in Unit 4.3 to learn how to align gears and assemble the gear box for the arm:

- Video 9: Align the Gears
- Video 10: Assemble the Claw Arm Drivetrain

Lesson 7: Students should watch the following videos in Unit 4.3 to add the Cortex microcontroller, check motion of gears and wheels, assemble the Claw arm, and finish the assembly of the Clawbot:

- Video 11: Add the Cortex Microcontroller
- Video 12: Assemble the Claw Arm
- Video 13: Complete the Robot Assembly

Lesson 8: Students should watch video 14 in Unit 4.3 to learn how to use Inventor Studio. They will render an image of the Clawbot as well as an animation of the Clawbot.

- Video 14: Render and Animate the Robot
- Summary Video

Students then watch the Summary video and reflect on what they have accomplished in their engineering notebook.

Engineering Notebook "Seed Questions":

1. Which items in the classroom require 3D modeling software to be designed and manufactured?
2. Which types 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?

Unit 5 Lesson Plan: THE GAME!

Grade Level:
9-12

Prerequisites:

9^{th} grade general math and science

Concepts Addressed:

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.

Learning Objectives:

- The students will be able to explain how the process of strategic design works.
- The students will be able to demonstrate the use of defining objectives to select game objectives.
- The students will be able to list all the ways to score the most points in the game.
- The students will be able to create a cost – benefit analysis to demonstrate the strengths of different tasks.
- The students will be able to correctly produce entries into their engineering notebook.

STEM Connections:

The interconnectedness 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.

Materials Needed:

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

Key Terminology:

- Strategic Design
- Defining Objectives
- Cost Benefit
- Prioritization

Day to Day Lesson Plan:

Day 1: Begin with the reasons of why Strategic Design is so important and work through Analysis of the Game.

Day 2: Continue with the Cost- Benefit Analysis Allow student teams to create a document where they can organize all the rankings that they will be assigning to tasks.

Day 3: Work through the Prioritization of Tasks and allow time for student groups to produce a chart to show how they went through the process.

Day 4: Student evaluation

Day 5: Review and concepts that need addressing

Engineering Notebooks
Assessment of vocabulary
Engineering Notebook
Review any concepts that were challenging for the students.

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?

Unit 6 Lesson Plan: Object Manipulation

Grade Level:

9-12

Prerequisites:

9^{th} Grade General Math & Science

Concepts Addressed:

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.

Learning Objectives:

- The students will be able to demonstrate the basic concepts of manipulators and accumulators.
- The students will be able to design examples of each.

STEM Connections:

Students use real world examples of manipulators found in their community.

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers

- Internet Access
- Dictionaries
- VEX Robotics Kit
- Storage containers
- Online Resources
- Computer with Autodesk Inventor

Key Terminology:

- <u>Manipulators</u>
- <u>Plow</u>
- <u>Scoops</u>
- <u>Traction</u>
- <u>Friction</u>
- <u>Claw</u>
- <u>Elasticity</u>
- <u>Accumulators</u>
- <u>Conveyor</u>
- <u>Magazine</u>
- <u>Indexing</u>
- <u>Hopper</u>
- <u>Conveyance</u>

<u>Day to Day Lesson Plan:</u>

Day 1:

Introduction to unit, Key Terminology Worksheet, Engineering Notebook

Find out what students already know about object manipulators.

Arrange students into teams to come up with definitions for key terminology.

Allow student groups to present their findings to the class or to their small teams.

Provide basic concept development.

Day 2:

Manipulators work on Terminology Worksheet, descriptions and explanations of each type of manipulators, students create a list in engineering notebook.

Review concepts from Day 1.

Allow student teams to research robotic manipulators in their community. Examples: Construction industry, manufacturing industry, and medical applications.

Students can make sketches into their Engineering notebook that feature each of the different types.

Students can also use Autodesk Inventor to sketch some of the manipulators that they find.

Day 3:

Presentation on accumulators

Complete and review vocabulary worksheet

Students will create a list and begin to make sketches in their engineering notebook on the descriptions and explanations of each type of accumulator

Students can also use Autodesk Inventor to show the types of accumulators

Day 4:

Activity Brainstorm, sketches in Engineering notebook, approval to start creation of an Object Manipulator

Explanation of the brainstorming process

Arrange students into teams and provide specific topics for brainstorming

Designs for Manipulators

Designs for Accumulators

Allow students to sketch or use Inventor to create plans for their manipulator

Day 5:

Begin the building process of the manipulator

Day 6:

Function testing and redesign

Day 7:

Finish any last-minute redesign

Presentation by groups on their robots

Day 8:

Engineering notebook submission

Post evaluation from group presentations

Opportunity to go back and review any concepts where students struggled.

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?

Unit 7 Lesson Plan: Speed, Power, Torque & DC Motors

Grade Level:

9-12

Prerequisites:

9th grade general math and science

Concepts Addressed:

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.

Learning Objectives:

- The students will be able to explain the difference between speed, power and torque.
- The students will be able to demonstrate the concept of speed.
- The students will be able to demonstrate the concept of power.
- The students will be able to demonstrate the concept of torque.

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.

Materials Needed:

- Unit Guide
- Paper
- Pencils with erasers
- Rulers
- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources
- Engineering Notebooks
- Protractor
- Compass

Key Terminology:

- Methodical
- Engineering
- Mechanics
- Speed
- Rotational Speed
- Acceleration
- Force
- Work
- Power
- Torque
- Velocity
- Actuator
- DC Motor
- Voltage
- Current
- Stall
- Load

Day to Day Lesson Plan:

Day 1: Provide students with the opportunity to look up the new vocabulary and to develop examples of speed, rotational speed, acceleration, and power. Allow for group discussion of terms.

You can provide additional information to correct and enhance the information that the students have gathered.

Cover the Following Topics from the Lesson Content:

Introduction

Engineering

Ask students what types of problems could be solved using the engineering process.

Ask students how they could use the engineering process to solve problems.

Classical Mechanics

Speed

Have students provide examples of speed.

Rotational Speed

Have students provide examples of rotation speed found in the classroom, the school, at home, and in the community.

Acceleration

Have students demonstrate the concept of acceleration

Force

Have students provide examples of how force is used in mechanics

Have students develop a demonstration the concept of force

Day 2:

Cover the Following Topics from the Lesson Content:

Torque

Allow the students time to work through math problems that support the classroom discussion on these topics.

Have students add the formula for torque to their engineering notebook for future reference.

Day 3:

Cover the Following Topics from the Lesson Content:

Work

Power

Day 4:

Cover the Following Topics from the Lesson Content:

DC Motors

Motor Loading

Current Draw

The Key Motor Characteristics

Varying Power with Voltage

Motor Limits & Calculations

Day 5:

Cover the Following Topics from the Lesson Content:

Arm Load Calculation

Torque Load Calculated from Current Limit

Motor Speed from Torque Load Calculation

Multiple motors

Work on calculations for voltage and motor limits.

Day 6:

Cover the Following Topics from the Lesson Content:

Arm Design

As part of the design process of a competition robot, it is possible a designer would use an arm structure like the ones that have been talked about earlier today.

Day 7:

Continue with Arm Design using VEX parts and or Autodesk Inventor

Check for detail in design

Check for integration of parts

Day 8:

Testing of arm designs. Data collection. Redesign.

Set up a location in the classroom where students can test their arm structures.

Check to see that data is recorded in Engineering Notebook.

Check for calculations used to make decisions on redesign.

Day 9:

Evaluation of arm structures.

Evaluation of the use of correct formulas and understanding of concepts presented in this unit.

Students can present their arm structures along with the explanation with formulas to the class.

Day 10:

Review concepts and formulas that were challenging for students.

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?

Unit 8 Lesson Plan: Mechanical Power Transmission

Grade Level:

9-12

Prerequisites:

9th grade general math and science

Concepts Addressed:

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 motor - arm systems seen on competition robots (and described in Unit 7.)

Learning Objectives:

- The students will be able to demonstrate how mechanical power transmission systems are very important in the design and construction of competition robots.
- The students will be able to vary the gear ratio (and the mechanical advantage) in a system, which gives them the versatility necessary to accomplish whatever work needs to be done.
- The students will be able to determine gear inputs & outputs by calculating the difference between them, and determine their gear ratio accordingly.

STEM Connections:

Mathematical concepts will be featured in terms of how a transmission functions.

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers
- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources

Key Terminology:

- <u>Gear</u>
- <u>Gear Ratio</u>
- <u>Mechanical Advantage</u>
- <u>Transmission</u>
- <u>Spur Gear</u>
- <u>Bevel Gear</u>
- <u>Crown Gear</u>
- <u>Worm Gear</u>
- <u>Helical Gear</u>
- <u>Idler Gear</u>
- <u>Epicyclical (Planetary) Gear</u>
- <u>Rack and Pinion Gear</u>
- <u>Gear Pitch</u>
- <u>Levers</u>

- <u>Compound Gear Reduction</u>

<u>Day to Day Lesson Plan:</u>

Day 1:

Introduce the unit with an explanation of how the transmission process works, or by having the students conduct research and present the information to their small groups who can then hold a peer review of the material. Include information from figures 8.1.1 through 8.3.
Student groups of three to four members will prepare a presentation that they will give to the class at the end of the unit that will include the different gear types and how they are used in the design process along with the math needed to support their choices.

Day 2:

Have the student groups conduct an experiment on carrying the 15 lbs. of books in a backpack up the stairs to study power.

Students will need to follow the methodical process that engineers use to solve a problem.

Student groups will conduct their own research and design an experiment to test their hypothesis.

Student groups will record their data and conduct an analysis.

Student groups will draw a conclusion based upon their data.

Day 3:

Review the different types of gears through a presentation or by having the students investigate the uses of different types of gears in equipment used in construction, farming, and industry. Use figures 8.4.1 through 8.11.1

Provide students with a variety of gears, which can be set up on simple structures to they can see how they work.

Day 4:

Gears - Include information on Teeth and Pitch and gear ratios, including Figures 8.12.1 8.12.1

Have the student groups design the different types of gear structures in Autodesk Inventor and show the class. Have them provide an explanation of how the gear structures work and what their advantage in the design process would be.

Alternative assignment will have the students sketch the different types of gears in their Engineering Notebook and explain the advantage of each type in the design process.

Day 5:

Levers - Find out what the students already know about levers.
Show how gears function in levers.

Include information from Figures 8.15.1 through 8.16.1

Students can demonstrate their prior knowledge through a series of sketches with a written explanation of how they work.

Day 6:

Gear Reduction - Review how the process works and the math needed to complete the calculations.

Review the material that includes the Figures 8.17.1 through 8.30.1
Worksheet with problems
(Needs to be created with solution sheet for the teachers.)

Day 7:

Continue the review of the gear reduction process.
Check for understanding of math concepts
Application of gears to DC motor systems

Day 8:

Students will revisit the arm design problem from the end of Unit 7.

1. The designers will create a single motor, gearbox, arm system that can lift the weight of a single game object, the manipulator from Unit 6.
2. The designers must choose an arm length appropriate for the game, which fits within the 18” robot size requirement. The gear ratio should be calculated such that the motor should be loaded such that it draws no more than one amp of current.
3. After calculating the necessary ratio, users must design a compound gearbox that achieves this ratio, and then calculate the final speed of the arm.

Day 9:

Assessment of vocabulary
Worksheet of calculations
Design ideas for their arm
Engineering Notebook

Day 10:

Review any concepts that were challenging for the students.

Engineering Notebook "Seed Questions":

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

Unit 9 Lesson Plan: Drivetrain Design

Grade Level:
9-12

Prerequisites:

9th grade general math and science

Concepts Addressed:

In this unit, students will learn about the physical principles of friction and traction through the exploration of robot drivetrain design.

Learning Objectives:

- The students will be able to demonstrate how applied force and friction are related.
- The students will be able to distinguish between static and kinetic friction.
- The students will be able to calculate wheel speed.
- The students will be able to demonstrate how to calculate a gear reduction.
- The students will be able to compare and contrast the different types of drivetrains, along with their benefits and drawbacks.

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.

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers

- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources

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
- Zero Radius Turn
- Ackermann Steering
- Skid Steer
- Omni Directional

Day to Day Lesson Plan:

Day 1:

Provide an introduction to the basic principles of friction and traction. Have the students identify examples of Friction, Traction, Static Friction, Coefficient of Friction, and Normal Force. After completing a review of the new vocabulary, the students will be able to come up with examples found at school, in their neighborhood and in industry.

Day 2:

Begin with The Drivetrain Terminology and work through Omni Wheels. Have students make sketches of the different types of drivetrains in their engineering notebooks. Make sure that they label their work.

Day 3:

Begin with Geometry and Turning of the Drivetrain and work through Turning Scrub.

Day 4:

Begin with the Design of a Turning Drivetrain and work through turning points.

Day 5:

Begin with Gear Train Design and work through calculations on gear reduction.

Day 6:

Begin with Motor Loading and introduce the Design Activity.

Day 7:

Continue with the Design Activity.

Day 8:

Allow for additional practice on calculations, design activity and concept review.

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?

Unit 10 Lesson Plan: Lifting Mechanisms

Grade Level:
9-12

Prerequisites:

9^{th} grade general math and science

Concepts Addressed:

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 assistance.

Learning Objectives:

- The students will be able to differentiate the three degrees of freedom that are presented in the beginning of the unit.
- The students will be able to demonstrate the correct use of the calculations needed to choose a gear reduction
- The students will be able to distinguish between the use of a linkage system and a multi-state elevator in manipulator design.
- The students will be able to explain how passive assistance can improve a robot design.

STEM Connections:

The major physics concept of degrees of freedom

The math components necessary to calculate the approach of a rotating joint

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers
- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources

Key Terminology:

- Object manipulators
- Lifting mechanisms
- Degrees of freedom
- First degree of freedom
- Second degree of freedom
- Third degree of freedom
- Shock load
- Joint loading
- Joint speed
- Mechanical advantage
- Factor of Safety
- Elevator
- Actuation
- Linkages
- Passive assistance

Day to Day Lesson Plan:

Day 1:

Provide an introduction on the basic principle of degree of freedom. Have the students conduct research of places where the three different degrees of freedom are found in their community.

Day 2:

Begin with the material on rotating joints up through the calculations on gear reductions at a rotating joint.

Day 3:

Review calculations on Approach 1 and Approach 2

Day 4:

Begin with the material on elevators and work through information on linkages. Students can find examples of linkage systems in common objects, tools and construction.

Day 5:

Begin with a presentation on the material covering the design of a lifting mechanism and work through the information on passive assistance. Students can make sketches or use Autodesk Inventor to create some simple designs to illustrate the different types of lifting mechanisms.

Day 6:

Introduce the Design Activity and provide time for the students to complete the brainstorming portion of the activity.

Day 7:

Continue with the design activity. Check to see that students are on task and that they are completing the appropriate calculations and making entries into their engineering notebook.

Day 8:

Have students present their designs to their classmates for peer review.

Day 9:

Allow additional time for students to make changes to their designs based on the peer review.

Day 10:

Allow for additional practice on calculations, design activity and concept review.

Day 11:

Evaluation of Engineering Notebook and Design Activity.

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 game objects.
2. Explain how a linkage system allows a robot to score on a high goal in a game situation.
3. Explain how passive assistance can provide your robot with a mechanical advantage.

Unit 11 Lesson Plan: Systems Integration

Grade Level:
9-12

Prerequisites:

9^{th} grade general math and science

Concepts Addressed:
In this unit the students will learn about 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.

Learning Objectives:

- The students will be able to demonstrate how system integration works.
- The students will be able to demonstrate how they can use the six tips of for integration in their design.

STEM Connection:

A major component of the design process includes the successful integration of all structural systems within the finished product.

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers

- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources

Key Terminology:

- <u>System Integration</u>
- <u>Power</u>
- <u>Control</u>
- <u>Pneumatics</u>
- <u>Drivetrain</u>
- <u>Lifting Mechanisms</u>
- <u>Object Manipulators</u>

<u>Day to Day Lesson Plan:</u>

Day 1:
Open the lesson with an introduction of system integration.

Day 2:
Introduce the design activity, which is the finishing of the competition robot.

Day 3:
Continue with the redesign or enhancement of their object manipulator and lifting mechanisms.

Day 4:
Students will work on the full models of their robot in Autodesk Inventor.
Alternative assignment students will complete all their hand drawings of their robot.

Day 5:
Students will continue their hands-on assignments of CAD work and robot construction.

Day 6:
Students will continue their hands-on assignments of CAD work and robot construction.

Day 7:
Assessment of engineering notebook
Assessment of Integration process through Inventor files and or hand drawn sketches

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?

Unit 12 Lesson Plan: Testing and the Iteration Process

Grade Level:
9-12

Prerequisites:

9^{th} grade general math and science

Concepts Addressed:
In this unit the students will learn how important testing, iteration and continuous improvement are in the design process. The students will learn how to develop their final design.

Learning Objectives:

- The students will be able to demonstrate the role that testing plays in the design process.
- The students will be able to demonstrate how the information collected in the testing process is used in the different iterations of their robot design.
- The students will be able to demonstrate a systematic process to prioritize the improvements dictated from the data collected from their testing.

STEM Connection:
The iterative process is fundamental in engineering. Keeping notes in an engineering notebook is common practice across the many types of engineering that exist.

Materials Needed:

- Unit Guide
- Paper
- Pencils
- Rulers
- Internet Access
- Dictionaries
- VEX Robotics Kit
- Computers with Autodesk Inventor
- Storage containers
- Online Resources

Key Terminology:

- Iteration

Day to Day Lesson Plan:

Day 1:
Introduce the process of iteration and how it is used in engineering.

Day 2:
Allow students to begin the testing process with the guided questions being answered in their engineering notebooks.

- Does the robot complete tasks in the desired manner?
- Is it fast enough?
- Is it robust enough, or are parts of it breaking during use?
- Does the robot achieve the goals that have been set forth by the team?
- Can it score enough points to consistently win matches?
- Is it easy to control?

Day 3:
Review how students should be using the information collected in their testing to prioritize the changes that need to be made to their robots.

- What is being tested?
- What results were observed?
- What could be done to improve the results?
- Are the results acceptable or is it worthwhile to make improvements?

Allow teams time to talk through this process and develop a written plan for which steps they will carry out first then second and so on.

Day 4:
Allow students to work on updating their Inventor projects and or their notebook sketches to reflect the new changes.
Have students show you their changes as they make the updates.

Day 5:
Allow for continued work on the Inventor projects and notebook sketches and for additional testing as needed.

Day 6:
Allow students to conduct any final preparation for the classroom competition.
Review Guide to Preparing for Competition in Appendix 4
Have students help in the preparation of a classroom competition. Refer to the VEX Guide to Holding a Competition in Appendix 3.

Day 7:
Class competition.

Day 8:
Complete Class Competition
Have students complete the Analysis and Reflection Questions into their Engineering Notebook

Day 9:
Final evaluation of Engineering Notebook
Evaluation of Inventor files/ notebook sketches

Engineering Notebook “Seed Questions”:

1. How did the testing process provide you concrete information to make your decisions?
2. How did the iterative process improve the quality of your design?
3. How did you prioritize which subsystems were working on first?

Analysis and Reflection Questions:

1. What was your favorite part of the competition robotics experience?
2. Did the game-play match your expectations (i.e. did the matches play out like you expected)?
3. What would you improve about your robot design?
4. Would you make any major changes or only minor changes?
5. What would you improve about the design process if you had to start over?
6. Were there things you wish you had spent more time on?
7. What was the most important life skill you learned during this process?
8. Why was it important to your experience?

Resources:

We ask our media specialist for copies of the engineering related magazines they have in the library. We also use YouTube to research ideas that others share about their robot designs and the way they program them to accomplish the tasks. We have the VEX curriculum that we follow which guides the students through the process of designing, building, and coding the robot to move the way you desire. We use Laptop computers for each robot to upload code at competitions. I have attended workshops and visited other school that have programs where students are successfully creating these robots, and bringing the information back to my students. I go to local home centers and construction companies to ask for their leftover materials to create things for the robots to interact with.

Materials we need to make our program successful are:
4 Vex Robotics Starter Kits @ $439.00 Each
Entry Fees for competitions the students wish to participate in range from $30 to $60 per robot entered.

Laptop computers for each robot to upload code at competitions

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