



Curriculum and Instruction

CTE Course of Study Outline

Title of Course of Study Robotics CTE

Course Number: _____ (Assigned by Curriculum Department)

CTE Course of Study Adoption Process		
PROCEDURES:		
1		Write/revise Course of Study. (If course is available at other district sites, all current teachers of that course must collaborate on the revision.)
2		Review with CTE Principal and acquire signature
3		Technology review if any technology components used (attach Tech Ticket)
4		If this course shares a CTE Pathway with CTE Teachers at other sites, email course of study to appropriate CTE sector staff at all high schools
5		CTE Administrator and CTE Teachers that share the same pathway review and discuss course of study and sign.
6		Course of study MUST be complete, including required signatures, and submitted to Curriculum Dept. 2 weeks prior to the scheduled Curriculum Council meeting.
7		Assistant Superintendent, Curriculum & Instruction - Review/Sign
8		Assistant Superintendent, Secondary Education - Review/Sign
9		Present course of study to Curriculum Council
10		Curriculum Council Recommends
11		Board of Education Approves

Note: Please complete all sections. Enter "none" or "n/a" as appropriate.

I. **Course Title:** Robotics CTE

II. **Industry Sector:** Information and Communication Technologies

Pathway Name: Systems Programming **Pathway Number:** 174A **Calpads:** 8132

CTE Course Level:

Introductory Course

Concentrator Course

☒ Capstone Course

Capstone Course (standalone 300+ hours)

Course of Study Proposal Reason:

☒ New Course

Curriculum Update

Textbook Update

UC/CSU a-g Update

Course Title Change

III. **Length of Course:** 1 year **Credit Value:** 10

☒ Meets Lodi USD high school graduation requirement credits

Elective course credit

No credit

IV. Grade:

9th
10th
☒ 11th
☒ 12th

V. Course Level:

~~General~~



Honors

Pre-AP

AP

VI. Is this an Internet-based course?

Yes ☒ No (e.g. Apex, Odysseyware...)

If so, who is the course provider?

VII. UC/CSU Approved Course:

Do you wish to submit this course to the UCOP to obtain UC/CSU a-g approval?

☒ Yes ☐ No

Is this course modeled after a UC-approved course from another district?

☒ Yes ☐ No If so, which school/district?

Santa Fe Christian School - Robotics (Area D)

VIII. Recommended UC/CSU Subject Area Pathway:

(Please complete each section as required by the UC system)

A. History/Social Science

E. Languages Other than English

B. English

F. Visual/Performing Art

C. Math

G. Elective

☒ D. Lab Science

IX. Subject Area Code for Lodi USD Graduation Requirements (select all that apply):

B. Fam Lvg/World Geography

L. Life Science

C. Economics

M. Mathematics

D. Driver's Ed

P. Physical Education

E. English

S. Physical Science

☒ F. Fine Arts/For Lang/CTE

U. US History

G. Government

W. World History

H. Health/Safety

Y. Elective

X. COURSE DESCRIPTION: Use this section to emphasize the core knowledge and skills students are expected to learn in the course, including concepts, theory and texts. There should be clear evidence of the course's level of rigor and the development of essential critical thinking skills.

The Course Description is comprised of three sections:

1. COURSE OVERVIEW:

Students will work in teams to design, build, and program robots using the VEX V5 robotics platform (vexrobotics.com). Students will learn the fundamentals of CAD & 3D printing, mechanical power transmission (leverage, gears, etc), and electronics (ohm's law, power, and DC motor curves). The final project will be to build a robot to compete in the annual VEX Robotics World Championship.

2. HIGHLY RECOMMENDED PREREQUISITES:

Programming with Python CTE (prerequisite)
Integrated Math 2 or equivalent (co-requisite)

3. COURSE CONTENT:

Students will be broken into teams of ~4 to complete the following 13 Units. To better prepare students for the roles they might see in industry, each team will have leadership positions including: Team Captain, Lead Mechanical Designer, and Lead Programmer.

Unit 1: Introduction to Engineering

Description:

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. Key objectives in this unit are: 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. The major engineering concepts including classical mechanics, Design, CAD, Prototyping, manufacturing, and iteration will be featured.

Summary of Lesson 1.3: What is Engineering Design Process

In this lesson, students will learn and understand the 6 steps (Define Problem, Generate Concepts, Develop Solution, Build/Test Prototype, Evaluate Solution, and Present Solution) to the engineering design process and the importance of each step. Students will define and discuss each step in Engineering notebook. Students will be asked to work in teams to build a tower to support an object. They will be given specifications and constraints that they must follow to complete the task. They will learn to collaborate on solving a problem while doing so within a fixed set of guidelines (specs and constraints).

Unit 2: Introduction to Robotics

Description:

In this unit students will learn about robotics in our world, and how the different aspects of STEM are all used in the field of robotics. This unit will also provide an introduction to the VEX Robotics Design System, students will get an overview of the different subsystems within the VEX system and how they interact together. Students will then put this knowledge into practice as they follow step-by-step directions to build their a robot. The STEM connections in this unit are: The concepts of how robots are have 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. Key learning objectives are: 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.

Summary of Lesson 2.3: Build a VEX Clawbot

The previous lessons will provide the basics about robotics and the VEX Robotics Design System. This lesson will provide the students a chance to work with the VEX Clawbot in an exciting activity that introduces the student to the world of robotics.

Unit 3: Introduction to VEX V5

Description:

In this unit, students will learn what the core components of the VEX control system are - the V5 Microcontroller, VEX V5 Joystick, VEX V5 Smart and VEX V5 Wireless link. They will also learn how they each function. Key STEM connections are: The concept of how the VEX V5 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 of the presentation. The Electronic controls provided by a programmable controller like the VEX V5 Microcontroller demonstrates that the robot is coordinate the operation of the different components and achieve its goal. Key objectives are: The students will be able to explain what the specific components that make up the VEX V5 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.

Summary of Lesson 3.5: The Can Clean-up Challenge

This challenge gives students the opportunity to test their robot and use the full range of its functionality. Students will set up 4 cans in a square (100 cm between cans) and be asked to pick up cans with their Clawbots and place as many cans as they can in a "goal" in 2 minutes. Each team will be given multiple opportunities to better their time. Once students feel more confident with user control, the challenge will move to a head-on-head competition between 2 groups. This lesson provides practice with driver control of the VEX Clawbot and increase the ability of groups to work as a team.

Unit 4: Introduction to Using CAD Software

Description:

In this unit, students will get an introduction to SolidWorks. They will get an overview of the different ways engineers use SolidWorks and then learn specific ways they can use Inventor to help design and build VEX robots. Key STEM connections are: Students will be using the software and math formulas to create and animate their 3D VEX models. Key objectives are:

The students will be able to create 3D models using SolidWorks. The students will be able to animate 3D models. The students will be able to render 3D models.

As local industry partners have encouraged us to explore using OnShape which they indicate is more widely used in the local high tech industry. I will be looking at ways to implement the lessons described using SolidWorks.

Summary of Lesson 4.2: Basic Inventor Command Overview

Students will use SolidWorks video tutorials and take notes in their Engineering Notebook to learn basic Inventor commands to be able to design their new Clawbot using Inventor. During this process, students will learn basic functions of Inventor and should be able to render a 3D model of a basic Clawbot and the end of this lesson.

Unit 5: The GAME!

Description:

In this unit students will be presented with a game (typically the VEX Robotics Competition game of the current competition season or one of the new VEX V5 STEM Labs). They will split into teams and then spend the this unit designing a robot which can play this game head-to-head against the robots built by their classmates. This robot build will follow the engineering design process discussed in Unit 1. The first step in this process is analyzing the design challenge placed in front of them and deciding what they want their robot to do. Students will have the option to join the school's VEX robotics team and compete in local competitions against other teams and see their design in action. They will be given opportunities through the rest of the year to analyze the effectiveness of their design and solutions, while asking them to make improvements based on their observations and seeing the results of those changes in future competitions.

Key STEM connections are: 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. Key student objectives are: 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 of 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.

Summary of Lesson 5.2: Strategic Design

Students will gain deeper understanding that strategic design is the process of determining what a robot should be able to do. In this process students are not trying to solve the problems of what the robot will look like, or how the robot will complete its tasks. Strategic Design occurs before both of those problems can and will be solved. It is impossible to build a successful competition robot without knowing what the robot is supposed to accomplish. This process will teach the students the importance of understanding the "final destination" prior to construction.

Unit 6: Object manipulation

Description:

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. Key STEM connections are: Students use real world examples of manipulators found in their community. Key objectives are: The students will be able to demonstrate the basic concepts of manipulators and accumulators. The students will be able to design examples of each.

Summary of Lesson 6.2: Manipulators

Students will research the 3 different forms of robotic manipulators (plows, scoops, and friction grabbers) and draw and describe the functions and benefits of each in their engineering notebook. Students will also compare pros and cons of each manipulator. This lesson will allow students to have the required knowledge to alter their VEX Clawbot to complete a challenge at the end of this unit that requires students to use manipulators in a challenge.

Unit 7: Speed, Power, Torque, and DC Motors

Description:

In this unit, students will learn about the physical principles of speed, power, and torque. They will also 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. Key STEM connections are: 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. Key objectives are: 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.

Summary of Lesson 7.3: DC Motors

Students will learn how actuators (VEX DC motors) drive everything that moves on a competition robot. Students will experiment with VEX motors, wheels, arms, and other apparatus to gain a deeper understanding of concepts such as motor loading, current draw, varying power with voltage, motor limits, arm loading, and arm torque. Students will record findings and calculation in engineering notebook for later reference and use in competitions.

Unit 8: Mechanical Power Transmission

Description:

In this lesson students will learn about the different types of mechanical power transmission. They will learn about different gear types, and how to calculate gear ratios. These principles will then be applied to the types of motor - arm systems seen in Unit 7. 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.) Key STEM connections are: Mathematical concepts will be featured in terms of how a transmission functions. Key objectives are: 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.

Summary of Lesson 8.8: Applying Gear Ratios to DC Motor Systems

Based on the lessons learned in Unit 7 and 8, students will analyze how adjustments to mechanical advantage will be important to the design of DC motor systems. Students will analyze and calculate how DC motors sometimes have current limits and must stay under load limits. Students will designs systems that require certain speeds, which motors must be geared up or down to achieve. Students will record findings and calculation in engineering notebooks.

Unit 9: Drivetrain design

Description:

In this unit students will be exposed to the physical principles of friction & traction while exploring the implications these principles have on robot drivetrain design. Students will be shown a variety of different robot drive system types and will learn the differences between them. Students will then apply the lessons they've previously learned about DC motors & gear ratios to design the powertrain of their robot's drive system. Key STEM connections are: 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. Key objectives are: 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.

Summary of Lesson 9.6: Design Activity

Students will use SolidWorks to choose a drivetrain for their competition robot and design it. Once the drivetrain is designed, students will build it on their competition robot using concepts learned in this and previous units.

This lesson may be updated to use OnShape as described in previous lessons to align with local industry guidance for our STEM classes.

Unit 10: Lifting Mechanisms

Description:

In this unit students will learn about 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 which are useful on competition robots. Students will then do preliminary design work on a mechanism for their robots. Key STEM connections are: The major physics concept of degrees of freedom and the math components necessary to calculate the approach of a rotating joint. Key objectives are: 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.

Summary of Lesson 10.8 Design Activity

Using the lessons learned in this unit, students should follow a design process similar to the one described in Unit 1 to determine a lifting mechanism for their competition robot. Students should brainstorm multiple solutions and record the entire process in their engineering notebooks. Students should choose one concept and design it in SolidWorks and/or build it using VEX Components.

Unit 11: System Integration

Description:

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. Key STEM connections are: A major component of the design process includes the successful integration of all structural systems within the finished product. Key objectives are: 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 for integration in their design.

Summary of Lesson 11.3: Finish Competition Robot

Student design teams should redesign or enhance their Object Manipulator from Unit 6, Drivetrain from Unit 9, and Lifting Mechanism from Unit 10. Students will combine these systems using the principles of Systems Integration described above to complete a full competition robot to play the game described in Unit 5. Design teams should fully model their robot in SolidWorks, and then build it out of VEX Robotics Design System components in real life. Once built, students should use their knowledge of the VEX System learned in Unit 3 to

wire & configure the robot to make it fully functional and ready for competition play. When designing your Competition Robot, ask yourself the following questions to get started:

- What Drivetrain do you want your robot to have?
- How is your robot going to manipulate the game objects?
- Will you need a lifting mechanism construction to achieve the competition Objective?
- How many motors are you going to have to use?
- Can you use Passive Assistance?
- Does your robot need speed or strength to be competitive?

To be able to complete this activity students should have a basic understanding of the SolidWorks user interface, navigation, and know how to work with Assemblies.

Unit 12: Testing and Iteration Process

Description:

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

Summary of Lesson 12.2: Testing and Iteration

In preparation for the final VEX competition, students will ask themselves many questions such as; Does the robot complete tasks in the desired manner? Is it fast enough? Is it robust enough, or are parts of it breaking or coming apart during use? Does the robot achieve the goals that have been set forth by the design team? After answering these questions, students should identify what areas they need to improve upon. At this point they should prioritize the improvements and begin working on the most pressing changes.

Unit 13: Design your Own Part or Robot

Description:

Unit 13 will end the year. In this unit, students will use SolidWorks and/or Autodesk Fusion 360 software to design and model their own custom part for addition onto their robot or robot. If possible, students will utilize rapid prototyping (3D printer)or CNC machine to create their part and implement it onto their robot before testing its efficiency. Key STEM connections are: 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 the VEX Classroom Lab Kit. They will employ design visualization through digital design software technology in conjunction with engineering

math formulas to create and animate their 3D models. Geometry and algebra calculations will be made with respect to forces and power requirements, engineering tolerances, degrees of freedom, finite element analysis, strength-to-weight ratios and kinematics. Key objectives are: The students will be able to analyze an existing product (VEX robot) to identify potential areas for innovation that might include improvements relative to performance or cost, among other factors. The students will be able to explain how physical sketch models, 2D sketches, and 3D digital models can be used as visualization tools for design ideation. The students will be able to use SolidWorks and/or Autodesk Fusion to create, render and animate custom 3D models. The students will be able to describe the importance of documenting and annotating a design in the design software. The students will be able to physically create a custom part from a virtual prototype using SolidWorks and/or Fusion.

Summary of Lesson 13.5: Design a Wheel

Students will watch 8 design videos and take notes in their engineering notebook to walk the student through the design and modeling of a Wheel for the Clawbot. This Wheel will be integrated into the Clawbot assembly. Once design is complete, students will use 3D printers to create wheel. Students will test designs on existing Clawbots.

XI. Texts and Supplemental Instructional materials:

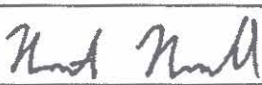
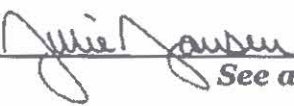
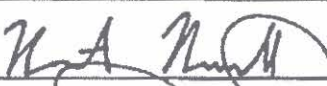




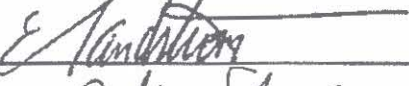


(Primary, Supplemental, newspapers, magazines, and software.)

Please supply ISBN #'s for all texts.

websites: <https://www.vexrobotics.com/>
<https://microbit.org/>

software: VEXcode V5: <https://www.vexrobotics.com/vexcode-download>
Ultimaker Cura: <https://ultimaker.com/software/ultimaker-cura>
Arduino IDE: <https://www.arduino.cc/en/software>

SolidWorks: <https://www.solidworks.com/sw/support/downloads.htm>

SIGNATURES for REVIEW		
Outline prepared by		Site: Lodi HS & Tokay HS
CTE Principal		Site: Lincoln Technical Academy <i>Teacher</i>
Technology Representative (if applicable)	<i>See attached Web Ticket</i>	
Teacher Representative:	Signature indicates course is aligned to CTE Model Standards.	** Please state reason for no signature in the space below.
Bear Creek High School	Not Applicable	Not taught at this site & no current CS Teacher
Lodi High School		
McNair High School		
Tokay High School		
Principal		
Lodi High School		
McNair High School		
Tokay High School		
Assistant Superintendent Curriculum & Instruction		
Assistant Superintendent, Secondary Education		

DATE	
9/3/2021	Date sent and/or presented to principal for review
9/3/2021	Course Outline Submitted
	Curriculum Council Recommendation for Approval
	Board of Education Approval