Glendale Unified School District

High School

November 5, 2019

Department:	Career Technical Education
Course Title:	Robotics Team Project 1-2
Course Code:	5475V/5476V
Grade Level(s):	9-12
School(s) Course Offered:	Clark Magnet High School
UC/CSU Approved (Y/N, Subject):	Yes, "g" College Preparatory Elective / Interdisciplinary
Co-requisites:	Integrated Math 2 or Higher
Integrated Academics (Y/N)	Yes
Recommended Prerequisite:	Physics (Recommended) Algebra 1 or Integrated Math 1 (Recommended)
Course Overview:	Robotics Team Project 1-2 is the first course for the Engineering and Architecture industry sector, Engineering Design Technology pathway. This laboratory-based integrated course is designed to support and facilitate student participation in the annual global FIRST Robotics Competition. Students will gain problem-solving abilities in engineering, robotics, computer programming, and business applications as they learn and apply the principles of engineering and manufacturing to this multifaceted competitive team project that emphasizes learning by doing. The student-centric design of the classroom lab environment promotes collaborative learning in small teams and personal skill development in particular specialty areas while allowing students to gain introductory knowledge in all areas of the course. The Robotics Team Project 1-2 course serves as a foundation for students to advance to the Honors Robotics Team Project 3-4 course in the following year.

Course Content-First Semester

Unit 1: **Industrial Safety** *(6 weeks)*

STANDARDS
Engineering and Design
Standards C 1.0
Key Standards: 1.1, 1.2
Common Core State Standards: RLST 11-12.2

A. In this unit, students learn industry-standard safety practices and procedures while gaining an understanding of the personal protective equipment used in each specific work process. General lab safety instruction includes lessons about evacuation routes and procedures, maintaining a clean and orderly workspace, use of compressed air, material safety data, locations of first-aid kits and fire extinguishers, lifting, and working with stored energy. A lesson on personal protective equipment discusses eye and ear protection, proper work attire, respiratory protection, and entanglement hazards.

B. Potential hazards in the lab are identified and proper use practices are emphasized for all equipment contained within the lab. These practices involve becoming familiar with safety mechanisms, controls, and guards related to specific machine tools, handling raw materials, securing work pieces, and inspecting the condition of tools prior to beginning work. Students then learn about safety precautions during work with machines such as avoiding distractions, maintaining one operator in control, and keeping hands away from machines that are powered on. Students apply their understanding of safety procedures by analyzing their own behaviors and identifying and preventing others from conducting potentially unsafe behaviors.

Unit Assignment(s): All students must pass a safety exam with a score of 90% or better before they are allowed to work in the lab. The exam is comprised of 60 multiple-selection questions covering all of the topics learned in the industrial safety unit including both general safety precautions and machine or process-specific precautions. Incorrect answers are re-evaluated and analyzed to clear any points of confusion or misunderstanding among students, to ensure the safety of everyone in the lab. All students must demonstrate their proficiency in safety on a continual basis as evaluated by ongoing formative safety reviews.

Unit 2: **Electronic Data Management** *(6 weeks)*

STANDARDS
Engineering and Design
Standards: C1.0, 3.0, 4.0
Key Standards: 1.1, 3.1, 4.1
Common Core State Standards: RLST 11-12.2, F-IF-1

A. Students will learn how to utilize, organize, manage, and maintain electronic data stored in a variety of locations. An emphasis is placed on following industry standard multi-user collaborative workflows while maintaining the preservation of original works and managing data revision history. Students will learn what a network file server is, the basics of data storage, redundancy, and backup. Students will utilize CIFS network shares, folder directory structures, and file naming conventions on a shared network server.

B. Additionally, students will learn to utilize a PDM server workflow through the use of Autodesk Vault software to maintain data integrity with Computer-Aided Design data in a multi-user project. Finally, students will learn how to import third-party electronic data from external sources such as online downloads into local and private server locations. After acquiring the aforementioned skills, students will spend substantial time to practicing the workflows including cross-site workflows and the transfer of data between on-site and off-site locations.

Unit Assignment(s): Students will be assessed in their electronic data management skills through a hands-on performance exam in which the student will physically demonstrate the following skills using a computer:

- Authenticate with the network file server using provided credentials, and map network shares as local drives.
- Navigate to a specified directory location at least five sub-folders deep within the directory structure.
- Copy data from one network location to another, appropriately organizing and naming the copy.
- Create CAD data, check it into the PDM server, verify another user's edits, and check the file back out to resume editing.
- Import downloaded data to the PDM server.
- Verbally explain the difference between a local drive and a network server indicating the use, benefits, and downsides of each.

Unit 3: **<u>Basic Computer Aided Design</u>** *(6 weeks)*

STANDARDS
Engineering and Design
Standards C3.0, C4.0, C5.0
Key Standards 3.1, 4.1, 5.1
Common Core State Standards: F-IF-1, G-CO-12, LS 11-12.4

A. Students will use the fundamentals of three-dimensional computer-aided design using parametric solid modeling software Autodesk Inventor. First, students will become familiar with the software interface including view navigation tools, the contextual ribbon bar, and the feature browser panel. Students will learn file types such as parts, assemblies, and drawings.

B. Students will begin with two-dimensional sketches drawn with geometric features such as points, lines, arcs, and polygons while utilizing geometric constraints such as parallel, perpendicular, collinear, equal, and tangent. Sketches will be transformed into three-dimensional solids using commands such as extrude and revolve.

C. Additional three-dimensional features will be employed such as holes, fillets, and chamfers. Students will learn how to view models from the three primary orthographic views and sketch on multiple planes. Finally, students will learn how to create assembly models of multiple parts by utilizing assembly mates and relationships.

Unit Assignment(s): Using a provided physical reference model, students will create a three-dimensional computer model of a robot gearbox. The assembly will consist of custom modeled plates and axles of the student's own design created from sketches, extrusions, fillets, chamfers, and hole features. Dimensional accuracy of the digital model of the gearbox plate will be checked to ensure proper placement of hole locations. Students will constrain their custom modeled plates and axles in a digital assembly with provided models of motors, bearings, and gears using assembly mates and relationships. The assembly model will be checked for proper placement of components, all components fully constrained, no component interference, and no inconsistent relationships between mates.

Unit 4: **<u>Mechanism Prototyping and Fabrication</u>** *(6 weeks)*

STANDARDS
Engineering and Design
Standards C2.0, C3.0 , C6.0
Key Standards : 2.1, 3.1, 3.2 , 6.1
Common Core State Standards: SEP-2, SEP-3, SEP-4,

A. In the Mechanism Prototyping and Fabrication unit, students will develop a potential solution to the challenge of acquiring, manipulating, and ejecting a physical object as described in the Engineering Challenge Analysis unit. To do so, students will construct physical prototypes of mechanisms from a variety of materials such as wood, plastic, and aluminum by applying multiple fabrication methods such as plasma cutting, saw cutting, drilling, sanding, bending, laser cutting, TIG welding, and CNC router cutting.

B. Both manual and computer-driven machinery will be used in conjunction with both manual sketches and measurements and 3D CAD models. Prototypes will undergo multiple iterations and refinements while students perform scientific data collection to analyze the device's accuracy and repeatability while identifying potential failure points. Key dimensional design parameters will be determined through a series of tests and iterations of the design.

Unit Assignment(s): Students will demonstrate their physical mechanism prototype in operation. The mechanism will be made from multiple materials, be produced via multiple fabrication methods, and may contain an assemblage of off-the-shelf components such as motors, gearboxes, sprockets, chains, wheels, and belt drives. The student will produce a written log of the results of testing the device over multiple trials, a written indication of any design revisions or changes, and speculation as to the source of any error and recommendations for improvement of the device.

Unit 5: **Precision Manufacturing** *(6 weeks)*

STANDARDS
Engineering and Design
Standards C4.0, 5.0, 6.0
Key Standards 4.2, 5.4, 5.5, 6.1
Common Core State Standards: SEP-4, SEP-5, 11-12.10

A. Students will be introduced to the concepts of milling and turning and the various tools and technology associated with each. Students will learn about the machine's axes of motion and workpiece fixturing devices such as chucks, collets, vises, and clamps. Students will gain familiarity with operating all of the machine controls for a standard Bridgeport-type milling machine and a standard 14x40 size engine lathe. Speeds and feeds will be covered as well as depths of cuts, types of cutting tools, and roughing and finishing passes.

B. Students will learn how to establish work origin points using an edge finder and other techniques and will use the digital readout to produce a part to provided specifications. Students will learn to use precision measuring devices such as dial and digital calipers to verify dimensional accuracy of the workpiece after machining operations.

Unit Assignment(s): In the first semester, students will use the knee mill and engine lathe to produce one milled bracket with hole features and one lathe-turned axle. The parts will each be produced from aluminum bar stock and will have threaded hole features. The parts must meet the dimensions on the provided drawing within a tolerance of +/- .003 inches. During the second semester, students will continue using the lathe and mill to create additional robot components such as hubs, axles, plates, box tubes, pivots, and brackets.

Unit 6: **Basic Mechanical Assembly** *(6 weeks)*

STANDARDS
Engineering and Design
Standards C5.0, C6.0, C8.0
Key Standards 5.1, 6.1, 8.1
Common Core State Standards: G-GMD-5

A. Students will learn how to assemble robot mechanisms using tools such as arbor presses, mallets, rivet pullers, wrenches, and hex drivers. An emphasis will be placed on parts inventory control and order of operations in assembly. Students will use a variety of fasteners such as rivets and socket head cap screws. Lubricants and retaining compounds will be covered, and students will develop a feel for proper torque of fasteners.

B. Students will understand the difference between inch and metric fasteners and will be able to visually identify fasteners with common thread types such as 10-32 or 1/4-20.

Students will learn how to measure and manufacture an ANSI roller chain to length and install the master connecting link.

Unit Assignment(s): Students will use various tools and fasteners to assemble a variety of robot mechanisms such as planetary gearboxes, spur gearboxes, riveted sheet metal components, and mechanisms containing bearings, belt drives, and chain drives. The correctly assembled and functioning mechanical assembly with all fasteners properly installed will demonstrate the student's proficiency in this area.

Course Content-Second Semester

Unit 7: **Basic Electrical Wiring** *(5 weeks)*

STANDARDS
Engineering and Design
Standards C3.0, C4.0,
Key Standards 3.2, 4.1, 4.2
Common Core State Standards: SEP-4

A. Students will understand American Wire Gauge and the tools and techniques used in assembling electrical wiring such as crimpers, wire strippers, and cutters. Students will learn how to measure and cut the wires to length, strip the insulation to an appropriate length, and properly crimp and assemble connectors such as Anderson PowerPole type connectors.

B. Students will learn Ohm's law and that larger diameter wires have less resistance than smaller diameter wires. Students will learn the difference between AC and DC current, identification of positive and negative voltages, and the role of circuit breakers in an electrical circuit.

C. Students will learn how to insert wires to WAGO style connectors and will learn how to use a digital multimeter to check for continuity, short circuits, and open circuits in different segments of an electrical system.

Unit Assignment(s): Students will wire the main power distribution system of a competition robot while meeting the following standards:

- Polarity is correctly indicated by wire color.
- Wire gauge is the appropriate size for the load, or as specified.
- Loads are connected to circuit breaker sized appropriately for the load.
- Connector terminals are fully seated within housings.
- Wires are stripped to appropriate lengths, and no bare copper strands are left exposed.
- Crimp connections appear proper and strong.
- The length and routing of the wiring is appropriate, neat, and orderly.
- The system has no short circuits or other faults and operates nominally.

Unit 8: **Pneumatic Systems** *(5 weeks)*

STANDARDS
Engineering and Design
Standards 4.0, 5.0
Key Standards 4.1, 4.2, 5.1
Common Core State Standards: CC-2, CC-3

A. Students will understand that pneumatic systems use compressed air as an energy source and are able to provide bi-directional mechanical motion of mechanisms with a force proportional to the product of the pressure and the area upon which the pressure acts. Students will realize that larger diameter air cylinders create more force, but consume more air. Students will learn to make conjectures about air consumption by applying their understanding of the ideal gas law to a pneumatic system that operates at a lower working pressure than the pressure stored in tanks.

B. Students will understand the role of each of the major components in a pneumatic system including the compressor, accumulators, regulators, gauges, ball valve, pressure relief valve, pressure switch, flow controls, solenoid valves, and cylinders. Students will become familiar with various styles of push-to-connect fittings and will be able to visually identify 1/8 NPT and 1/4 NPT threaded fittings. Students will understand the difference between single-acting and double-acting solenoid valves and be able to select the appropriate valve for the application.

   Unit Assignment(s): Students will assemble and install a complete functioning pneumatic system to the robot vehicle that contains all the proper components and is free of leaks. The student will verbally be able to explain path the air flows throughout the entire system, starting from the compressor, working through the tanks, regulator, and valves and ending up at the cylinders. The student will correctly identify what pressure each segment of the system operates at and will correctly identify which valves operate which cylinders.

Unit 9: **Introduction to Controls and Software Development** *(5 weeks)*

STANDARDS
Engineering and Design
Standards 2.0
Key Standards 2.1, 2.2, 2.3
Common Core State Standards: SEP-1 - SEP-5

A. Students will learn the essentials of control systems as they pertain to implementation upon a FIRST competition robot. Topics will include wireless network communications, operator console configuration, software deployment from the integrated development environment, and utilization of the WPI code libraries in conjunction with the Java programming language.

B. Students will learn how to read control inputs from USB devices on the operator console and proportionally map them into commands that control the robot's motors and actuators as outputs. Students will learn the basics of object-oriented programming, logical structures, variable types and definitions, loops, functions, and timers. After learning how to program the robot for direct teleoperated control, students will experiment with autonomous control via dead reckoning techniques based on time and distance.

Unit Assignment(s): Students will develop two robot programs written in the Java language. One will be for teleoperated control, and one will be for autonomous control. The teleoperated control program will demonstrate logical mapping of the operator's controls as inputs to the robot's motors and pneumatic actuators as outputs. The autonomous program will demonstrate that the robotic vehicle, without human input, can drive forward a specified distance, turn a specified angle, actuate a mechanism for a specified amount of time, and actuate a pneumatic cylinder at the correct time in the routine. The autonomous program will be shown to be repeatable when run through multiple trials.

Unit 10: **Event Logistics Operations** *(5 weeks)*

STANDARDS
Engineering and Design
Standards C1.0, C2.0,
Key Standards 1.1, 2.2
Common Core State Standards: ETS1.A, ETS1.B, 11-12.4

A. This unit focuses on the physical logistics associated with travel to competitive robotics events. Students will learn to prepare checklists, complete necessary paperwork, and gather and pack tools, supplies, and support equipment needed for the event. Students will learn how to handle, roll, maneuver, and secure both heavy and delicate cargo while loading and unloading the support equipment cargo trailer that travels to competition events. Students will become practiced in operating load-securing devices such as ratchet straps.

B. An emphasis is placed on proper packing and handling techniques to avoid damage to equipment. Students will learn how to assemble a 10x10 expo booth containing numerous multimedia displays and multiple pieces of support equipment for the robot vehicle.

Unit Assignment(s): Students will be provided a 1-hour time to pack and stage equipment at the school lab, a 1-hour time to load the cargo trailer, a 30-minute time to unload at the event, and a 2-hour time to set up the expo booth at the event. Within these allocated times, students will demonstrate the following proficiencies:

- Equipment packing and staging is orderly with nothing left behind. Written checklists are used.
- The trailer loading demonstrates proper item placement for weight distribution over the tongue and axles.
- Cargo is secured in a fashion such that it cannot move, and will not experience

damage due to highway vibration
- Equipment is unloaded expediently at the event venue.
- Rolling equipment is handled with care on slopes, through doorways, and across thresholds.
- The expo booth area setup is completed within the 2-hour window including flooring, carts, banners, lights, electrical cabling, and multimedia displays.

The Event Logistics Operations unit repeats a minimum of three times annually.

Unit 11: **Graphic Design and Marketing** *(5 weeks)*

STANDARDS
Engineering and Design
Standards C1.0, C11.0,
Key Standards 1.1, 11.1, 11.2
Common Core State Standards: RLST- 11-12.7, PE-12.1

A. Students will learn the difference between raster and vector images and will learn how to convert a raster image to vector by multiple methods including edge detection, brightness cutoff, and color quantization. Students will use Adobe Illustrator and Inkscape software to manipulate vector images and prepare them for cutting on a computer-controlled vinyl cutter or printing on a professional color laser printer with booklet maker.

B. Students will also learn how to prepare graphics for screen printing, and work to arrange team sponsor logos and graphics in a visually appealing way for printing to team t-shirts and informational brochures. Students will learn the concepts of measurement, scale, aspect ratio, and proportion as they manipulate vector graphics. Students will apply and adhere to a brand standard consisting of fonts, color selections, and logo usage guidelines to maintain the team's established brand.

Unit Assignment(s):

Printed Brochure - Students will design and produce an 8-page printed and v-folded brochure containing photos and informational text about the robotics team to serve as a recruitment tool for new students. The student will learn how to arrange graphics on a page layout, select colors, and prepare the file for printing, and configure printing options for a color laser printer with professional booklet maker. The brochure will be proofread and free of spelling, grammatical, and graphical errors.
Vinyl logos -Students will produce adhesive-backed vinyl logos using from a vector graphic file using a computer controlled cutting machine. Students will learn how to weed the negative space in the logos, apply transfer tape, and apply the logos to a vehicle while maintaining alignment and ensuring the application is free of bubbles and wrinkles.

Unit 12: **<u>Photography and Videography</u>** *(5 weeks)*

STANDARDS
Engineering and Design
Standards C1.0, 11.0
Key Standards 1.2, 11.1, 11.2
Common Core State Standards: RLST- 11-12.7, WS-11-12.6

A. Students will document their work and experiences through all aspects of the robotics team project using both photos and videos. Students will learn how to compose and frame their shots, what sort of things and moments make an appealing image, and what to leave out of images. Students will become proficient at operating digital camera equipment and will understand terminology such as zoom, focus, exposure, brightness, ISO setting, resolution, compression, codec, file type, and file size.

B. Different students will be tasked with photography and video recording different aspects and elements of the robotics project and competition experience, for ultimate use by students in the Honors Robotics Project 3-4 class, who will then produce finished works from the raw stills and footage collected. Students will provide each other feedback about the quality of their images as they work to develop an eye for what looks "good.

Unit Assignment(s): Students will deliver a collection of their "20 best" photos and video segments which they will load onto the team's centralized file server. In order to accomplish this task, students will have to spend significant time sifting through their collection of photos and videos gathered throughout the year and pulling out only those that are truly worthy or unique enough to be included within the "20 best" classification. Through this self-review process, students will develop a sense of what composes a quality and meaningful photographic or video image.

Unit 13: **<u>Data Collection and Strategic Planning</u>** *(5 weeks)*

STANDARDS
Engineering and Design
Standards C2.0, 5.0
Key Standards 2.2, 5.1
Common Core State Standards: CC- 1-2, SEP-4, SEP-5

A. This unit takes place at the robotics competition events using a web-based computerized system developed by the students. Students will observe robotics competition matches, input data to the online system, and collaboratively create a massive dataset of "scouting data" comprised of multiple competitive match performance attributes for each of the six teams competing over a series of approximately 100 competition matches. When complete, the dataset will feature more than 3,000 data points.

B. Students will use techniques of statistical analysis to analyze the trends of competing teams through looking at averages, minimums, maximums, and performance graphs over time which will indicate consistent, rising, or declining performance. The results of the analysis will be used to plan a strategy for upcoming matches in which our own team competes.

Unit Assignment(s): The major assignment for this unit is creation of the massive scouting dataset. Students must attentively observe the competition matches and accurately input the observed data into the system. Any errors or omissions in the data set can lead to false averages, so the entire set is checked for accuracy on an ongoing basis. On a regular basis throughout this process, students will verbally report approximately 10 times on the analysis of a set of 5 teams competing in the same match as our own. The duration of this instructional unit lasts 2.5 days over approximately 20 hours at the competition event. This unit repeats three times annually.

Unit 14: **Vehicle Performance Demonstration** *(5 weeks)*

STANDARDS
Engineering and Design
Standards C1.0, C2.0,
Key Standards 1.1, 2.1, 2.2, 2.3
Common Core State Standards: CC-2, CC-6,

A. At multiple points throughout the school year including at two official and one or more unofficial competition events, students will demonstrate the performance of the robotic vehicle they designed and manufactured through a series of tournament matches against other teams. In total, the robot will compete in a 2.5-minute competition match approximately 50 times in one year. Preparing the vehicle for each competition match is a significant effort requiring strategic planning and communication with the other teams competing, systems checks of every mechanism and subsystem on the vehicle, regular maintenance of fasteners and drive systems, repair of damage due to collisions, and loading and verification of new software updates.

B. During each competition match, student drivers and operators are commanding the vehicle's motions to perform a certain task, while other students are taking video and collecting data. After each match, the data and video is reviewed, and adjustments are made for the next competition match.

Unit Assignment(s): The assignment for this unit really consists of the team of students fielding a successful vehicle that performs well in the tournament over a series of approximately one dozen competition matches. Through this process, students learn the value of teamwork, determination, and continual improvement through iteration. The measurable result of their efforts is the win-loss record of the team at each tournament.