La Cañada High School

Proposed Course Outline – Robotics

I. **Course Title –** Robotics

II. **Grade Level(s) –** 9-12

III. **Length/Credit –** 1 year / 10 Credits

IV. **Preparations –** Algebra 1 Required / PLTW 1, 2 or 3 Recommended

V. **Course Description**

Students will continue their work from prior courses to work in engineering teams to design, build and test increasingly complex robots. The course will illustrate the importance of integrating sensors, complex machine control, and briefly discuss robot learning and multi-robot systems. Students will be expected to solve challenges using physical robots and computer simulations. Students will work in teams to complete a larger design problem and participate in local and regional competitions. Special attention will be paid to the design process and its communication through both presentation and documentation. Students will explore additional hardware and software solutions to robotics problems. Students will learn advanced hardware and software techniques, as well as the mathematics and physics to understand them. Students will use additional hardware and software platforms to understand robotics applications (Arduino, parallax, etc.)

VI. **Standards/ESLRs Addressed**

California English Common Core Standards

RH.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.
RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11—12 texts and topics.
RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
W.11-12.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
W.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when

appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and over-reliance on any one source and following a standard format for citation.
SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.9-10.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
SL.11-12.4 Present information, findings, and supporting evidence (e.g., reflective, historical investigation, response to literature presentations), conveying a clear and distinct perspective and a logical argument, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. Use appropriate eye contact, adequate volume, and clear pronunciation.

California Math Common Core Standards

Understand ratio concepts and use ratio reasoning to solve problems.

California CTE Standards

CTE.ED.B.B3.1 Analyze relationships between voltage, current, resistance, and power related to direct current (DC) circuits.
CTE.ED.B.B3.5 Use appropriate electronic instruments to analyze, repair, or measure electrical and electronic systems, circuits, or components.
CTE.ED.C.C3.1 Know how the various measurement systems are used in engineering drawings.
CTE.ED.C.C3.2 Understand the degree of accuracy necessary for engineering design.
CTE.ED.C.C8.2 Use tolerancing in an engineering drawing.
CTE.ED.C.C8.1 Understand what constitutes mating parts in engineering design.
CTE.ED.C.C6.2 Apply dimensioning to various objects and features.
CTE.ED.C.C10.2 Use sketching techniques as they apply to a variety of architectural and engineering models.
CTE.ED.C.C10.1 Understand the process of producing proportional two- and three-dimensional sketches and designs.
CTE.ED.C.C5.2 Know the various object-altering techniques.
CTE.ED.C.C5.4 Apply two-dimensional and three-dimensional CADD operations in creating working and pictorial drawings, notes, and notations.
CTE.ED.C.C5.3 Know the CADD components and the operational functions of CADD systems.
CTE.ED.C.C5.1 Understand the commands and concepts necessary for editing engineering drawings.
CTE.ED.C.C5.5 Understand how to determine properties of drawing objects.
CTE.ED.C.C2.3 Apply the concepts of engineering design to the tools, equipment, projects, and procedures of the Engineering Design Pathway.
CTE.ED.FS.10.2 Understand the importance of technical and computer-aided technologies essential to the language of the Engineering and Design sector.
CTE.ED.FS.10.4 Acquire, store, allocate, and use materials and space efficiently.

CTE.ED.FS.10.6 Understand and apply the appropriate use of quality control systems and procedures.
CTE.ED.FS.2.0 Communications
CTE.ED.FS.5.3 Use critical thinking skills to make informed decisions and solve problems.
CTE.ED.FS.5.2 Understand the universal, systematic problem-solving model that incorporates input, process, outcome, and feedback components.
CTE.ED.FS.5.1 Apply appropriate problem-solving strategies and critical thinking skills to work-related issues and tasks.
CTE.ED.FS.11.0 Demonstration and Application
CTE.ED.FS.9.3 Understand how to organize and structure work individually and in teams for effective performance and attainment of goals.
CTE.ED.FS.4.2 Understand the use of technological resources to gain access to, manipulate, and produce information, products, and services.
CTE.ED.FS.4.3 Understand the influence of current and emerging technology on selected segments of the economy.
CTE.ED.FS.4.1 Understand past, present, and future technological advances as they relate to a chosen pathway.
CTE.ED.D.D5.6 Build a prototype from plans and test it.
CTE.ED.D.D5.3 Choose between alternate solutions in solving a problem and be able to justify the choices made in determining a solution.
CTE.ED.D.D5.7 Evaluate and redesign a prototype on the basis of collected test data.
CTE.ED.D.D5.5 Understand the process of developing multiple details into a single solution.
CTE.ED.D.D5.2 Determine what information and principles are relevant to a problem and its analysis.
CTE.ED.D.D5.1 Understand the steps in the design process.
CTE.ED.D.D5.4 Translate word problems into mathematical statements when appropriate.
CTE.ED.D.D6.5 Calibrate and measure objects by using precision measurement tools and instruments.
CTE.ED.D.D6.4 Estimate and measure the size of objects in both Standard International and United States units.
CTE.ED.D.D6.3 Use tools, fasteners, and joining systems employed in selected engineering processes.
CTE.ED.D.D6.1 Know the common structure and processes of a quality assurance cycle.
CTE.ED.D.D6.2 Understand the major manufacturing processes.
CTE.ED.D.D2.1 Assemble the components of a telecommunications system or subsystem, including confirming operating parameters, applying test procedures, and making necessary adjustments.
CTE.ED.D.D8.2 Install and configure the main computer hardware and software components.
CTE.ED.D.D8.6 Understand the process of testing and troubleshooting computer equipment and systems.
CTE.ED.D.D8.1 Understand how to design systems that use computer programs to interact with hardware.
CTE.ED.D.D8.4 Know the function and interaction of basic computer components and peripherals.
CTE.ED.D.D11.3 Apply the concepts of engineering technology to the tools, equipment, projects, and procedures of the Engineering Technology Pathway.
CTE.ED.D.D11.2 Apply conventional engineering technology processes and procedures accurately, appropriately, and safely.
CTE.ED.D.D11.1 Use methods and techniques for employing all engineering technology equipment appropriately.
CTE.ED.D.D4.1 Understand scalars and vectors.

CTE.ED.D.D4.2 Solve problems by using the concept of vectoring to predict the resultant forces.
CTE.ED.D.D4.3 Know the six simple machines and their applications.
CTE.ED.D.D3.8 Calculate loads, currents, and circuit-operating parameters.
CTE.ED.D.D3.7 Understand how electrical control and protection devices are used in electrical systems.
CTE.ED.D.D3.1 Analyze relationships between voltage, current, resistance, and power related to direct current (DC) circuits.
CTE.ED.D.D3.6 Classify and use various electrical components, symbols, abbreviations, media, and standards of electrical drawings.
CTE.ED.D.D3.5 Analyze and predict the effects of circuit conditions on the basis of measurements and calculations of voltage, current, resistance, and power.
CTE.ED.D.D3.4 Use appropriate electronic instruments to analyze, repair, or measure electrical and electronic systems, circuits, or components.
CTE.ED.D.D3.3 Calculate, construct, measure, and interpret both AC and DC circuits.
CTE.ED.D.D9.1 Use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data in a simulated or modeled automated system.
CTE.ED.D.D9.2 Understand the use of sensors for data collection and process correction in an automated system.
CTE.ED.D.D9.5 Assemble input, processing, and output devices to create an automated system capable of accurately completing a preprogrammed task.
CTE.ED.D.D9.3 Program a computing device to control an automated system or process.
CTE.ED.D.D9.4 Use motors, solenoids, and similar devices as output mechanisms in automated systems.
CTE.ED.D.D1.5 Prepare reports and data sheets for writing specifications.
CTE.ED.D.D1.3 Know the current industry standards for illustration and layout.
CTE.ED.D.D1.1 Understand the classification and use of various electronic components, symbols, abbreviations, and media common to electronic drawings.
CTE.ED.D.D10.2 Understand charting and the use of graphic tools in illustrating the development of a product and the processes involved.
CTE.ED.D.D7.2 Understand how the laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.
CTE.ED.D.D7.1 Understand Newton's laws and how they affect and define the movement of objects.
CTE.MPD.FS.9.5 Understand how to interact with others in ways that demonstrate respect for individual and cultural differences and for the attitudes and feelings of others.
CTE.MPD.FS.9.1 Understand the characteristics and benefits of teamwork, leadership, and citizenship in the school, community, and workplace settings.
CTE.MPD.FS.9.3 Understand how to organize and structure work individually and in teams for effective performance and attainment of goals.
CTE.MPD.FS.5.3 Use critical thinking skills to make informed decisions and solve problems.
CTE.MPD.FS.5.2 Understand the universal, systematic problem-solving model that incorporates input, process, outcome, and feedback components.
CTE.MPD.FS.5.1 Apply appropriate problem-solving strategies and critical thinking skills to work-related issues and tasks.
CTE.MPD.FS.4.2 Understand the use of technological resources to access, manipulate, and produce information, products, and services.

California Academic Content Standards

M.8-12.G.6.0 Students know and are able to use the triangle inequality theorem.

VII. Brief Course Outline

Unit 1 - Lab Safety
Students complete a safety course compliant with S/P2 OSHA course in lab safety. This course involves curriculum that teaches students how to be safe in an engineering lab environment.

Unit Assignment(s):
Students will pass a written exam comparable to the S/P2 OSHA exam with 90% or better. Students will pass a hands-on assessment demonstrating the proper use of tools, machinery, and equipment used in the classroom.

Unit 2 - Engineering Design Process

This unit is designed to reinforce and further explore the engineering design process, the engineering design concepts of mechanics, form, fit and function, and applications of Newton's Laws of Motion as they work in teams to design an underwater remotely operated vehicle (UROV).

Unit Assignment(s):
Students will identify the problem/need, research existing solutions, brainstorm solution, choose a plan, produce a prototype, test and present their solutions. Students will use a lab notebook throughout the course, with protocols structured around the design process. Students will interpret information such as sensor and motor specification sheets to make calculations, and will document their designs clearly in industry-standard visual and written formats.

- Student work will be assessed by evaluating the measured speed vs calculated speed, written analysis of variances between the two, and by the quality of their design process as reflected in their lab notebook.
- After reading informational text on underwater vehicles, and viewing a video on underwater vehicles, students will research online and write a 3-5 page technical research paper evaluating the usefulness of underwater vehicles and their practical uses in society.
- **Underwater Romotely Operated Vehicle Project**. Designing a vehicle to compete in the MATE ROV Competition. After reading and viewing informational text on the "game", students will identify the problem/need for which they will design a vehicle, define working criteria and goals, research and gather data, brainstorm and analyze potential solutions, choose a plan, produce a prototype, and test and present their solutions. This exercise will engage students in collaborative teams using the engineering design process, and in applying basic physics concepts from previous coursework. Students will be introduced to the use of CNC machines to fabricate their vehicles, and will practice lab safety protocols. Student work will be assessed by evaluating the measured speed vs calculated speed, written analysis of variances between the two, and by the quality of their design process as reflected in their lab notebook.
- **Research and Evaluation of Options:**After reading informational text on underwater vehicles, students will research online and write a 5 page technical research paper evaluating the usefulness of underwater vehicles and their practical uses in society.

Unit 3 - Advanced Construction

Students will continue their work from Robotics to work in engineering teams to design, build and test increasingly complex robots.

Unit Assignment(s):

The course will illustrate the importance of integrating sensors, complex machine control, and briefly discuss robot learning and multi-robot systems. Students will be expected to solve challenges using physical robots and computer simulations. Students will work in teams to complete a larger design problem and participate in local and regional competitions. Special attention will be paid to the design process and its communication through both presentation and documentation. Students will explore additional hardware and software solutions to robotics problems. Students will learn advanced hardware and software techniques, as well as the mathematics and physics to understand them. Students will use additional hardware and software platforms to understand robotics applications (Arduino, parallax, etc.)

Unit 4 - Advanced Arms and Lift Systems

Students will use the principles of Force, Weight, Torque, Gears, and Mechanical advantage to design new and more robust lifting systems for their robots.

Unit Assignment(s):

Students will also be introduced to pneumatic and hydraulic actuators as a component of robotic lift systems as well as in industry. Software such as Inventor and MDSolids will be used to predict the stress/strain on parts during the lifting process. The limitations of motors and other design constraints will be approached in both a theoretical and practical manner. Special attention will be paid to build quality, adaptability, and modularity.

Unit 5 - Advanced Sensors

Introduces the student to closed loop robotic navigation and lifts using sensors in both positive and negative feedback loops.This unit will focus on the devices used in developing DC circuits. Wires, resistors, LED's, and switches will used in circuits designed by students to perform simple tasks.

Unit Assignment(s):

This unit builds on the programming learned in prior courses. All students will incorporate complex feedback systems (PID control, etc) and other algorithms in the design process. Gyroscopes, accelerometers, and vex LCD modules will be added. Sensors beyond the scope of VEX robotics will be considered as well. Students will learn the difference between analog and digital sensors and compare/contrast their uses and abilities.

Unit 6 - Programming

Students will use the programming language, to design and develop an intelligent real-time system that can complete a set of complex pre-programmed task, using sensors to collect data and actuators to self-correct.

Unit Assignment(s):

Students utilize advanced “for loops,” “while loops,” case structures and “sub VI’s”, and work with multiple variables, arrays and clusters. Students will also apply mathematical concepts from previous course work such as solving linear equations and utilizing slope. They will then program their robotic device to complete the tasks outlined in Unit 3 (autonomous and joystick control). Finally, students construct and program a pneumatic arm and gripper assembly for their robotic device, which must be able to complete complex tasks defined by the U.S. First Robotics competition instructions. Student-produced programs are evaluated based on the efficacy of the program in getting the robotic device to perform as required. The culminating activity for this unit is the industry based exam.

- Students will individually create a project presentation that follows the engineering design process. Beginning with this second semester iteration of the engineering design process: identifying the problems their device was modified to address, referencing the research they found that was most useful to their work, evaluating the design modifications they considered, articulating their rationale for the design solutions they developed, introducing their documentation and identifying the mathematical principles applied therein.
- Student teams will demonstrate their prototypes to a panel of industry partners with team project report presentation, including appropriate documentation, who will evaluate using a rubric that includes presentation content and skills, strength of documentation, and the capacity of the robotic device to meet requirements.
- **Program Robot Movements:** Students will program their robots to move autonomously and via joystick commands. Students will add code necessary for their robot to navigate through a pre-established obstacle course. To successfully navigate through the obstacle course, students will have to add code utilizing various sensors and motors. Once the robot completes its autonomous functions, a joystick controlled challenge will be presented. When both challenges are complete, the program will be complete.
- **The Project Report:** Students will individually create a project presentation, that follows the engineering design process. Beginning with this second semester iteration of the engineering design process: identifying the problems their device was modified to address, referencing the research they found that was most useful to their work, evaluating the design modifications they considered, articulating their rationale for the design solutions they developed, introducing their documentation and identifying the mathematical principles applied therein.

With the use of the lab notebook and the engineering design process throughout this course, the majority of the course is composed of hands-on activities that could be classified as labs. Because the design process proceeds through stages, the final lab reports are the project reports at the end of Units 3 and Unit 6. In addition, there are some places in the course where students are experimenting with engineering design and physics concepts in classic science lab mode:

1) **Gearbox Lab:** Students will apply the physics concept of work and torque to understand the impact of different gear ratios on their robot motors, noting their observations in their lab notebooks. Students will be guided through calculations to predict the effects of gears on known weights, and write up their findings in their lab notebooks. Students will use their findings to develop a custom gearbox for their robotic device and support evidence for their Machine Power report.

2) **Lights On.** To familiarize students with a simple circuit and to facilitate students' grasp of Ohm's Law, students will design and build a simple circuit that turns on an LED. Students will also use a multi-meter to measure the current and voltage in their newly created circuit to validate Ohm's Law. Using a variable resistor, students will log resistance, voltage, and current data in their lab notebooks. Students will then be asked to add a switch to their design. Students will be assessed by a 2 page reflection describing how their simple circuit relates to their robot design.

Although lectures, quizzes, and homework assignments will be utilized, students spend time during each unit completing project work. Students use hand tools, power tools, analog and digital measuring devices, CAD, 3-D modeling software, probe-ware, data analysis software, CNC machines, online resources, and simulations as they engage in a variety of activities that balance direct instruction with laboratory and project work. Methods of instruction will include, but are not limited to those listed below.

Direct Instruction

For some engineering concept and skill development, instructional methods will include structured overviews, interactive lectures and practice. Teacher-facilitated discussions generated by teacher-formulated, open-ended questions will help students develop the analytical thinking skills to question and pose solutions for real world business problems. Teacher modeling of problem solving techniques and data analysis coupled with guided practice will help students develop innovative ways to manipulate, represent, analyze and draw conclusions regarding experimental data.

* Interactive Lectures and Demonstrations
* Guided Practice
* Homework and Independent Practice
* Teacher Modeling

Lab Work and Data Analysis

Labs provide an authentic opportunity to collect and analyze data using the appropriate tools of science and engineering. Thus, students are expected to design their own lab procedures, given only the materials provided to them, including coming up with their own questions and hypotheses. Students are responsible for collecting, creating a visual representation, and analyzing data. In some cases, the procedures will be provided. In these cases, students will be asked questions to guide their representation and interpretation of the data gathered.

Lab Notebook:

Using the protocol designed around the engineering design process, this journal will be kept throughout the course, and provide a structured protocol for recording data, developing designs, and reflecting on progress. The lab notebook will provide essential material for the final project report.

Student Led Discussions

Wrapping up activities and/or labs will often wrap up in the form of student-led discussions. Students present, discuss, argue, and/or agree on each group's evidence-based conclusions. Students ask each other questions regarding their experiment or conclusions using academic language. The teacher will facilitate discussions, but will not evaluate students' responses. The teacher may rephrase unclear questions while making sure the reiteration of the question was the intended one.

Project Work

In the course of completing projects, students engage in many of the instructional strategies mentioned above. However, they will also be completing assignments that pertain to creating a final product that is the culmination of their project work. This may include the production of an artifact (technical drawing, model, prototype, device, or report), or it may involve preparing for and delivering a presentation to the class, teacher, or a panel of relevant guests and experts. Preparation of artifacts and presentations represents a synthesis of many of the concepts and skills developed within the context of the earlier scaffold assignments.

Unit 7 - Competition

Students will adapt their design to compete in various robotics competitions (e.g. First Robotics, VEX, MATE) at both the local and regional level.

Unit Assignment(s):

Students will finalize both Autonomous and User-Controlled programs using sensor input to compete. Students will prepare presentations to demonstrate their design process and how their robot accomplished the design task. Students will also use their programming skills to complete new levels of challenges. Students will use this chance to perform outreach events, and to display their work and design to local school and community partners. Students will be expected to mentor less experienced teams, as well as volunteer to judge or facilitate local competitions.

Students will be asked to compare their designs to those that exist in industry to apply any design changes or describe the constraints that control their use.

Students will investigate potential use of platforms such as Arduino, parallax, and LabVIEW to design, program and control robotics systems. Students will apply these platforms to an advanced topic of their choosing, possibly in conjunction with other engineering classes or competitions.

VIII. Methods of Assessment

Written and verbal reports and assesmsents, participation in competitions, discussions and skills demostration.

IX. **Materials/Textbook(s)**

Teacher created materials
Websites such as S/P2 OSHA Safety Training (http://www.sp2.org/site) How Stuff Works (http://auto.howstuffworks.com/fuel-efficiency/vehicles/solar-cars1.htm)

X. Seeking "a-f" Approval – Yes. College-Preparatory Elective (G) / Laboratory Science – Physical Sciences

XI. Seeking AP Class Approval – No.

C:/Course.out/Proposed Course Outline Template