Program Course Description Template

(Required information needed for course submission)

Program Information

Program Name: UC Davis Center for Integrated Computing and STEM Education (C-STEM)

Contact Person

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SECTION A. BASIC COURSE INFORMATION

Course Title: Computing with Robotics (C-STEM)

Transcript Abbreviation(s) / Course Code(s): Computing w/ Robotics

NOTE: Schools are responsible for providing the above information.

Length of Course:

☐ Half Year (1 semester; 2 trimesters; 2 quarters)
☒ Full Year (2 semesters; 3 trimesters; 4 quarters)
☐ Two Years (4 semesters; 6 trimesters; 8 quarters)

Subject Area / Discipline:

NOTE: See attached [Appendix A] for all subject areas and disciplines.

Subject Area: College-Preparatory Elective
Discipline: Mathematics/Computer Science

UC Honors Designation:

Is this course being submitted for UC honors consideration?

NOTE: 9th grade courses are not eligible for UC Honors consideration.

☐ Yes ☒ No

Grade Level:

NOTE: Grade level pertains to which grades the course has been designed.

☐ 9 ☒ 10 ☒ 11 ☒ 12

Course Learning Environment:

Is this course, or any separate section of this course, taught in an online learning environment?*

☐ Yes ☒ No

If "Yes," has your institution conducted a self-assessment of the online course against the iNACOL Standards for Quality Online Courses?

☐ Yes ☐ No

If "Yes," does the course fulfill all 15 UC-identified power standards from the iNACOL Standards for Quality Online Courses?

☐ Yes ☐ No

If "Yes," how many of the remaining 37 standards from the iNACOL Standards for Quality Online Courses the course satisfy? _ ______

*Please ensure to attach a copy of your completed Online Course Self-Assessment Form.

Is this course an integrated course?

NOTE: UC encourages the development of integrated courses that combine and skills of traditional academics with contextualized learning in career technical education.

☒ Yes ☐ No

If "Yes," please indicate the Industry Sector and Career Pathway below:

NOTE: See attached [Appendix B] for all industry sectors and career pathways.

Industry Sector: Information and Communication Technologies (ICT)
Career Pathway: Software and Systems Development

SECTION B: COURSE DESCRIPTION

Course Overview:

Briefly (in a short paragraph) provide a brief summary/snapshot of the course's content:

This course introduces students to the working principles and foundational knowledge of robotics. Students learn to control a single robot and multiple robots by graphical user interface, and computer programs in C/C++. Students write robotics programs to perform various tasks based on the sensory information of robots. Robots are used as platforms to engage students in both personalized and collaborative learning computing, science, technology, engineering, and math concepts. This course emphasizes hands-on robotics activities with a concentration on mathematical modeling and computer programming for solving problems in math and science. As term projects, students will participate in regional and statewide C-STEM RoboPlay Video and/or RoboPlay Challenge Competitions, which not only enhance their learning of robotics, math, and engineering, but also allow them to explore their creativity in writing, art, music, choreography, design, video editing, and film production. Through these project-based team activities, students develop critical thinking, problem solving, effective communication, and teamwork skills.

Pre-Requisites: Algebra I or Integrated Mathematics I, Required x Recommended _______

NOTE: Laboratory science and Advanced VPA courses require a pre-requisite. Some courses require appropriate pre-requisites. Please refer to the "A-G" Guide for more information.

Co-Requisites: ______________________________ Required ______ Recommended _____

Course Content:

For each unit of the course, provide:

1) A brief description (5-10 sentences) of topics to be addressed that demonstrates the critical thinking, depth and progression of content covered.
2) A brief summary (2-4 sentences) of at least one assignment that explains what a student produces, how the student completes the assignment and what the student learns.

Unit One: **Introduction to Motion Control and Robot Programming**

This unit introduces the students to how a computer works and the importance of computing in the 21st century. Students learn the basics of robot programming and programming language syntax in C/C++ using the C/C++ interpreter Ch. The modular robot Linkbot is used as a platform for this course. First students are introduced to the major features of the Linkbot, how to run the demo program, pose teaching, tilt drive and copycat modes. Students learn to calibrate the zero positions of the joints and the importance of the right-hand-rule for motion. Through the interactive graphical user interface (GUI), Linkbot Labs, students test the joint positions, connect the Linkbot to their computer, move joints through the motion control panel, and access the sensory information of the accelerometer and on board LED. Students write their first Linkbot program, needing to understand how to move the robot joints relative to their current positions. Using member functions of robot classes in C++, students will drive the Linkbot forward and backward. RoboBlockly is used to further introduce computer programming for robots. Ch Linkbot Controller is used for scaffolding the control of one and two Linkbots with dynamically generated Ch code.

As a sample task, with a partner, students will create an obstacle course for the Linkbot to travel through. Students will practice navigating their obstacle course using the accelerometer in one Linkbot to control another though tilt drive mode. The simulation can be performed in RoboBlockly first. Afterwards students will use their knowledge of robot programming to write a Ch program controlling the Linkbot to traverse the obstacle course autonomously.

Unit Two: **Robot Simulation with RoboSim**

In this unit students are introduced to the robot simulation environment RoboSim with virtual robots. Students will control virtual robots with the same Ch code that controls physical hardware robots. In RoboSim students will learn how to configure the grid where the Linkbot travels on, how to change units between metric and imperial units, and how to turn the trace on and off to see the exact path the Linkbot travels on. Through RoboSim students will have the option to add their own robots or use one of many preconfigured robotic systems with multiple Linkbot modules. Students will use their mouse or track pad to interact with the RoboSim scene; either zooming in/out or panning left to right. Students will complete the unit learning RoboSim specific functions to move the Linkbot along a specific trajectory and recording the positions of the Linkbot on the RoboSim X-Y coordinate system.

The Linkbot function **robot.drivexyTo(),** available in RoboSim, is a great way for students to discover that a graph of a linear equation is the set of its solutions plotted on a Cartesian plane. Students write code that takes a line with positive slope and plots the solutions of the line for the x-values from 0 to 10 on the RoboSim coordinate plane. Once this is done, the code moves the virtual robot through the same points using the function **robot.drivexyTo()** in RoboSim . Students work in pairs to run the code with and without the tracing functionality. As another task, using advanced features in RoboSim students will program a virtual Linkbot to trace out their initials in the robot simulation environment. Students will need to determine specific algebraic functions to draw out the letters of their name and program the Linkbot to move along those trajectories. The program will turn the trace on and off when appropriate.

Unit Three: **Computer Programming for Controlling Robots**

In this unit students learn the importance of the input/output functions **printf**() and **scanf**(). Students learn formatted input and output making their program meet specific design criteria. Students understand the difference between variable data types **int** and **double** and when it is appropriate to use each. Students apply their knowledge of data types to robot programming making a two-wheeled Linkbot move a specified distance through the user input. Students will also understand how to make the Linkbot turn a specified angle right or left through user input. Students will use repetition statements with "**while**" and "**for**" loops to control how many times a series of statements are executed. Students will use **if-else** conditional statements to selectively choose specific Linkbot motions based on the user input. Students will understand the importance of looping in computer programming. Students will apply the C statement "**break**" to exit early from "**for**" and "**while**" loops.

Using repetition statements students will program a Linkbot to travel in a circle with the radius of 8 inches. Using markers or tape the instructor will create a circle of radius 8 inches and place it on the floor. Students will program their Linkbot to travel around the circle with the perimeter passing between the two wheels of the Linkbot. If one of the wheels crosses the perimeter the student must start over from the beginning. Students can also write a program to interactively control a Linkbot through the keyboard input. Using a **while** loop, the program will be set up so that if the user presses the 'w' key the Linkbot will move forward, 's' will move the Linkbot backwards, and 'a' and 'd' will turn the Linkbot left and right. Additionally the user can use keys for 1, 2, 3 and 4 to set the speed ratio of the Linkbot.

Unit Four: **Writing Advanced Programs to Control a Single Linkbot**

In this unit students will write advanced programs to control a single Linkbot with different motion characteristics. Students will understand how to use multiple motion statements within a program as well as the difference between moving joints to their absolute versus relative to current positions. Students will write programs that report back the current joint angles of the Linkbot to ensure the robot is traveling the correct distance. Students will appropriately use delays and learn to both get the current joint speed and set the speed faster or slower to accomplish specific tasks. Students will learn to set the joint speeds as a ratio of the maximum speed and how to convert between degrees and radians. Students will learn the importance of plotting in computer programming and how to use the plotting member function in Ch. Students will plot recorded joint angles vs. time and analyze the output graph. Students will understand how to move the Linkbot's joints for a user specified amount of time, how to hold the joints at exit, and measure the clock time using the member function **robot.systemTime**() to time the motion of a robot.

Students will create a physical Tic-Tac-Toe grid where each square measures 1 foot by 1 foot out of tape or simple materials. Developing understanding about the functions of the Linkbot and programming syntax, students use **robot.move(), robot.moveTo(),** and **robot.driveDistance()** functions in their program navigating the grid they created. Students will practice with hardware Linkbots challenging their fellow classmates. For increased difficulty students can write the program to calculate the distance needed to travel based on the angle of rotation and the circumference of the Linkbot's wheels.

Unit Five: **Writing Programs to Control Multiple Individual Linkbots**

In this unit students will control multiple Linkbots first using the motion control panel in Linkbot Labs. Students will then transit their knowledge into controlling multiple Linkbots using a program they wrote. Students will understand the difference between blocking and non-blocking functions and their importance in getting multiple Linkbots to move simultaneously. Students will learn to synchronize the motions of multiple Linkbots simultaneously. Students will move multiple Linkbots with specified distances, joint angles, or for specific times. Students will copy motions of a leading Linkbot to a follower Linkbot. Using the advanced features of the robot simulation environment RoboSim, students will create a virtual obstacle course with points, lines and text. Students will move multiple Linkbots in the RoboSim X-Y coordinate system. Students will move multiple Linkbots along different trajectories, and record the time and positions of multiple Linkbots.

Students will write a program to simulate the passing of a baton in a relay race using three Linkbots. All robots will begin with their LEDs set to red. When the first robot begins to move, its LED changes to green, while the second and third robots remain stationary with red LEDs. When the first robot runs into the second one, the accelerometer of the second robot responds to the bump and begins moving with a green LED. The first robot then stops and changes its LED back to red. The same pattern continues for the interaction between robots two and three.

Unit Six: **Controlling Single and Multiple Two-Wheel Robots for Applications in Math and Science**

In this unit students will control a Linkbot-I configured specifically as a two-wheeled robot. In this configuration students will move the Linkbot specified distances, time, and angles. Through the user input students will control the Linkbots speed and distance values. Students will read information from the Linkbot regarding how far it has traveled and estimate the error in the movement. Students will use specific functions to convert distance to angles and angles to distance based on the circumference of the Linkbot's wheels. Students will use the computer clock to get the time for the two-wheeled Linkbot to move a specific distance at a specific speed thus reinforcing the concepts of distance, speed, and time. Students will create plots of distance versus time both starting at the same point and with an offset. Students will understand how to use different units for speed, radius, and distance and their applications in math and science.

The motion of multiple Linkbots can be performed in RoboBlockly first. Students will then use RoboSim and hardware Linkbots and the graphics utility in Ch to solve systems of linear equations with an offset. With one Linkbot placed at the origin, another is placed some distance in front of it. The Linkbot in the lead will start moving at a constant speed determined by the instructor. After some delay time, the second Linkbot will begin moving at a constant rate. Students will determine when and if the Linkbots will meet thus solving the system of two linear equations. Any system of linear equations can be modeled and solved similarly.

Unit Seven: **Sensory Information for a Linkbot**

In this unit students will both get and set the LED on the Linkbot either using strings or looking up the RGB values. Students will learn to program the piezoelectric buzzer to play certain frequencies. Students will also learn how to read accelerometer data from the Linkbot and view the current battery voltage. Students will measure and alter sensory information on physical Linkbots and through RoboSim. Using a **while** loop students will copy motions of a leader Linkbot to a follower Linkbot. Students will read accelerometer data from one Linkbot and use it to alter the LED color of another.

Students will write a program to use the accelerometer data of one Linkbot to set the LED color of another Linkbot. First, they will sound the buzzer of the first Linkbot at 450 Hz and set its LED to green. Then using a **while** loop, students will do the following multiple times in succession: get the X, Y, Z components of the accelerometer data; calculate the R, G, B values based on these components; set the LED to a new color using these RGB values.

Unit Eight: **Controlling Groups of Linkbots and Film Production for RoboPlay Video Competition**

Working as a team, students will control groups of Linkbots with synchronized motion. Students will control an array of Linkbots to have identical movements. Students will use the arrays of Linkbots to make a short choreographed dance. Students will copy the motions from one Linkbot to multiple Linkbots with identical movements. Students will control multiple Linkbots in small groups. The C-STEM RoboPlay Video Competition is designed for students to learn robotics while having fun and exploring their creativity in writing, storytelling, art, music, choreography, design, video editing and film production and at the same time seamlessly learning Computing and STEM subjects. The necessary robot coordination to match the movement of multiple modules to music requires not only teamwork in designing a well-organized visual performance, but also the math and programming skills to produce the desired actions. The teamwork involved in the RoboPlay Video Competition will engage all students, including those who are inclined to pursue careers in the arts or humanities.

Students will modify the task in Unit Three adapting it to groups of Linkbots. Through user input, the group of Linkbots will move forward, backwards, or side-to-side based on specific keystrokes. In groups of 4 or 5, students will work on making an array of Linkbots perform a choreographed dance. Students will program Linkbot motion to sync to any particular style of music of their choosing. Based on the rules for RoboPlay Video Competition, student teams will make short 2-5 minute videos with robotics in the context of a global problem. Students will submit their videos to the RoboPlay Video Competition. More information about RoboPlay Video Competition can be found at: http://c-stem.ucdavis.edu/c-stem-day/

Unit Nine: **Controlling Multiple Connected Linkbots and RoboPlay Challenge Competition**

Students will work with partners to control multiple Linkbots connected to form one robot system such as snake, four-legged walker, explorer, and humanoid. Students may use a pre-configured or custom configuration. Individually, students will become familiar with programming the pre-configured Linkbot options in RoboSim. Students will use pose teaching to program the Linkbots and analyze the machine generated code. Students will learn to control multiple Linkbot-Ls and how to control a group of connected Linkbots with identical movements. The C-STEM RoboPlay Challenge Competition is designed for students to showcase their real-world problem solving skills in a competitive environment. The competition simulates an unexpected problem occurring at a remote location such as a space station or planetary habitat, where a robotic solution must be quickly developed and deployed, using only existing resources. The competition challenges students to creatively use modular Linkbots and accessories to complete various tasks. The competition arena and specific challenge will be kept secret until the day of the competition. Using their math, programming, and problem solving skills, students try to most efficiently get the highest score for each task.

In groups of 3 - 5, students will work on completing past C-STEM Day RoboPlay Challenge Competition challenges. All previous challenges can be found at: http://c-stem.ucdavis.edu/c-stem-day/. Student teams can also participate in the RoboPlay Challenge Competition in May each year on C-STEM Day.

(Please feel free to add as many unit fields as necessary.)

SECTION C: COURSE MATERIALS

Primary Textbook:

NOTE: Include list of primary and secondary course materials. Course materials help UC understand what materials are used to support student learning and the delivery of the course.

Title: Learning Robot Programming with Linkbot for the Absolute Beginner

Edition: 6th

Publication Date: May 2016

Publisher: UC Davis C-STEM Center

Author(s): Harry H. Cheng

URL Resource(s): http://c-stem.ucdavis.edu

Usage: x_____ Primary Text x_____ Read in entirety or near entirety

Software: Ch Professional Edition

Developer: SoftIntegration, Inc.

Website: http://www.softintegration.com/download/

Software: C-STEM Studio

Developer: UC Davis C-STEM Center

Website: http://c-stem.ucdavis.edu/downloads/

Software: Linkbot Labs

Developer: Barobo, Inc.

Website: http://c-stem.ucdavis.edu/downloads/

Supplemental / Secondary Instructional Materials:

NOTE: Please list any other course materials here. These may include but are not limited to: literary texts, manuals, periodicals, articles, websites, primary documents, multimedia, etc.

Secondary Textbook:

NOTE: Include list of primary and secondary course materials. Course materials help UC understand what materials are used to support student learning and the delivery of the course.

Title: Learning Computer Programming with Ch for the Absolute Beginner

Edition: 2nd

Publication Date: May 2016

Publisher: UC Davis C-STEM Center

Author(s): Harry H. Cheng

URL Resource(s): http://c-stem.ucdavis.edu

(Please feel free to add as many unit fields as necessary.)

[APPENDIX A] — SUBJECT AREAS / DISCIPLINES

NOTE: For detailed information on all subject requirements, please visit the A-G Guide.

_____ ("a") – History / Social Science

- _____ U.S. History
- _____ American Government / Civics
- _____ World History / Geography / Cultures

_____ ("b") – English

- _____ English
- _____ English as a Second Language (ESL)/ English Language Development (ELD)

_____ ("c") – Mathematics

- _____ Algebra 1; Yr 1 of 2
- _____ Algebra 1; Yr 2 of 2
- _____ Algebra 1
- _____ Mathematics I
- _____ Geometry; Yr 1 of 2
- _____ Geometry; Yr 2 of 2
- _____ Geometry
- _____ Mathematics II
- _____ Algebra 2; Yr 1 of 2
- _____ Algebra 2; Yr 2 of 2
- _____ Algebra 2
- _____ Mathematics 3
- _____ Algebra 2 / Trigonometry
- _____ Advanced Mathematics
- _____ Statistics
- _____ Computer Science

_____ ("d") – Laboratory Science

______ Biology

______ Chemistry

______ Physics

______ Earth and/or Space

______ Integrated Science

NOTE: Students that enroll in an integrated-science program (ISP) are strongly advised to complete the entire three-year sequence. In most cases, the first year of an integrated-science sequence fulfills only the "g" elective requirement; the second and third years of the sequence then fulfill the two-year "d" laboratory science requirement. Accordingly, if only ISP I is successfully completed, then two courses from the categories of Biology, Chemistry, or Physics in the “d” subject area must be completed. If ISP I and only one of ISP II or ISP III are completed, then one additional course from the categories of Biology, Chemistry, or Physics from the “d” subject area must be taken to fulfill the "d" requirement.

______ Interdisciplinary Science

NOTE: This category demonstrates that the course is cross-disciplinary and is often used for advanced science courses such as AP Environmental Science or Biochemistry.

______ (“e”) – Language Other than English

______ LOTE Year 1

______ LOTE Year 2

______ LOTE Year 3

______ LOTE Year 4+

Language:

_______ American Sign Language (ASL)

_______ Arabic

_______ Chinese

_______ French

_______ German

_______ Hebrew

_______ Italian

_______ Japanese

_______ Latin

_______ Other

_______ Russian

_______ Spanish

______ (“f”) – Visual & Performing Arts

______ Dance

______ Music

______ Theater Arts

______ Visual Arts

______ Interdisciplinary Arts

x______ (“g”) – College-Preparatory Elective

______ History / Social Science

______ English

x _____ Mathematics / Computer Science

______ Laboratory Science—Biology / Life Science

______ Laboratory Science—Physical Science

______ Laboratory Science—Earth / Space Science

______ Laboratory Science—Interdisciplinary Science

______ Laboratory Science—Integrated Science

______ Language Other than English

______ Visual & Performing Arts

______ Interdisciplinary

[APPENDIX B] — INDUSTRY SECTORS / CAREER PATHWAYS

NOTE: This applies to integrated courses only.

______ Agriculture and Natural Resources

- _______ Agricultural Business
- _______ Agricultural Mechanics
- _______ Agriscience
- _______ Animal Science
- _______ Forestry and Natural Resources
- _______ Ornamental Horticulture
- _______ Plant and Soil Science

______ Arts, Media, and Entertainment

- _______ Media and Design Arts
- _______ Performing Arts
- _______ Production and Managerial Arts

______ Building and Construction

- _______ Cabinetmaking and Wood Products
- _______ Engineering and Heavy Construction
- _______ Mechanical Construction
- _______ Residential and Commercial Construction

______ Education, Child Development and Family Services

- _______ Child Development
- _______ Consumer Services
- _______ Education
- _______ Family and Human Services

______ Energy and Utilities

- ______ Electromechanical Installation and Maintenance
- _______ Energy and Environmental Technology
- _______ Public Utilities

_______ Residential and Commercial Energy and Utilities

______ Engineering and Design

_______ Architectural and Structural Engineering

_______ Computer Hardware, Electrical, and Networking Engineering

_______ Engineering Design

_______ Engineering Technology

_______ Environment and Natural Science Engineering

______ Fashion and Interior Design

_______ Fashion Design, Manufacturing, and Merchandising

_______ Interior Design, Furnishings, and Maintenance

______ Finance and Business

_______ Accounting Services

_______ Banking and Related Services

_______ Business Financial Management

______ Health Science and Medical Technology

_______ Biotechnology Research and Development

_______ Diagnostic Services

_______ Health Information

_______ Support Services

_______ Therapeutic Services

______ Hospitality, Tourism, and Recreation

_______ Food Service and Hospitality

_______ Food, Science, Dietetics, and Nutrition

_______ Hospitality, Tourism, and Recreation

x _____ Information Technology

_______ Information Support and Services

_______ Media Support and Services

_______ Network Communications

x ______ Programming and Systems Development

______ Manufacturing and Product Development

_______ Graphic Arts Technology

_______ Integrated Graphics Technology

_______ Machine and Forming Technology

_______ Welding Technology

______ Marketing, Sales, and Service

_______ E-Commerce

_______ Entrepreneurship

_______ International Trade

_______ Professional Sales and Marketing

______ Public Services

_______ Human Services

_______ Legal and Government Services

_______ Protective Services

______ Transportation

_______ Aviation and Aerospace Transportation Services

_______ Collision Repair and Refinishing

_______ Vehicle Maintenance, Service, and Repair