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

First Name: Harry

Last Name: Cheng

Position/Title: Professor/C-STEM Center Director

Phone Number: (530) 752 – 9082

E-mail: info@c-stem.ucdavis.edu

SECTION A. BASIC COURSE INFORMATION

Course Title: Algebra 1 w/ Computing & Robotics (C-STEM)

Transcript Abbreviation(s) / Course Code(s): _____
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: Mathematics
Discipline: Algebra 1

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:

The course guides students through topics in Algebra 1 in Common Core State Standards for Mathematics while simultaneously teaching students programming and computational thinking. Students use programming in C/C++ interpreter Ch to reinforce and extend their knowledge of mathematical concepts by analyzing real life situations, identifying given information, formulating steps that a computer program could calculate to find a solution, analyzing the results for accuracy, and revising/modifying the programming solutions as necessary. Topics covered include solving one-variable equations with multiple steps, solving and plotting absolute value equations and inequalities, linear equations, systems of linear equations and inequalities, polynomial functions, exponential functions, and step and piecewise functions, evaluating, multiplying, and factoring polynomial functions, solving quadratic equations with applications, probability, statistical data analysis and visualization, and arithmetic and geometric sequences. Robotics activities allow students to reenact physically derived mathematical problems through robotics technologies, such as RoboBlockly and RoboSim via C-STEM Studio, to visualize situations, associate linear and quadratic graphs with physical phenomenon, predict and identify key features of the graphs with robotic systems, and solve robotics problems through mathematical modeling and programming.

Pre-Requisites: _____   Required _____   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 Computing and Robotics/Operations with Real Numbers and Expressions**

This unit introduces students how a computer works and the importance of computing in the 21st century. Students learn the basics of programming and programming language syntax in C/C++ using the C/C++ interpreter Ch. Students evaluate expressions, practice order of operations, and examine properties of rational numbers in a Ch Command Shell. Students write proper programming language syntax to review and practice basic operations with real numbers, order of operations, and manipulating and evaluating variables in simple algebraic equations. Students demonstrate their understanding of properties of rational and irrational numbers through a utility program. To meet the challenges of this unit, students persevere in solving specific problems with attention to precision, construct variable arguments and critique the reasoning of others, and model with mathematics. Throughout this unit, students understand problems that arise in real life context of programming and find solutions of multi-step problems, choose and interpret the problems with formulas and conceptual understanding, and choose and interpret the scale of measurement. These skills are demonstrated in multi-tiered tasks throughout the unit and students apply their knowledge and understanding of basic programming syntax, number sense, expressions, and equations to create mathematical models.

For example, students develop a program that verifies the routes describe in an Orienteering Scavenger Hunt with specified starting and end points. The program calculates the distance traveled between the two points or at each pit stop. At each stop, students demonstrate their mastery of Unit One mathematical concepts on real numbers, expressions, and equations. Groups of students swap obstacle courses to create a program for robots to traverse, and students evaluate the accuracy of the course map developed based on the descriptions given.

Unit Two: **Using Functions and Robotics for Math Application**

In Unit Two, students learn function notation and develop the concepts of domain and range in terms of real-life situations. Students explore four types of functions (sequences, linear, quadratic, and exponential) and interpret them graphically, numerically, symbolically, and verbally. Comparing and contrasting linear and exponential functions, students interpret arithmetic sequences as linear functions and geometric sequences as exponential functions. Students work as a development project team to construct programs in Ch that define a function, call the function using correct syntax, and debug it. Constructing graphs of functions using **plot.func2D()** and **plot.expr()** with arguments specific to the graphed function, students graph quadratic functions with transformations. Students integrate a variety of media into development projects and develop programs that control the motions of robots using **robot.driveDistance()** and **robot.drivexyToFunc()**.

For example, interpreting functions numerically, symbolically, and verbally, students write a program that directs a robot's motions to be based on distance, time, and different speeds. Students create a table of inputs and outputs for the distance equals speed multiplied by time function with different speeds. Then, students diagram a flowchart for the mathematical procedure. Next, students write a program that uses

the code **robot.drivexyToFunc()** to direct a robot's motions with different speeds used and prints a list of distances traveled by the robot.

Unit Three: **Linear Models and Solving Linear Equations and Inequalities**

In this unit, students work on multiple tasks that integrate concepts of mathematics, software development, and robotics. Students connect (algebraically and graphically) the concepts of two-dimensional lines and systems of linear equations using robots and programming. The robot simulation environment RoboSim with virtual robots is used to show that the graph of a linear function is the set of all ordered pair of solutions plotted on a Cartesian plane. Also, RoboSim and Ch Linkbot Controller are used to show the meaning of the solution to a system of two linear equations in terms of real-life situations. Robots are used to deepen the students' understanding of what a line is and what it means for two lines to intersect. Through this unit, students learn to plot the entire solution to an equation in two variables, learn to graph equations while displaying their data, and learn to run the code to explore what happens when one changes the speed or distance a robot travels. Students make sense of the true meaning of the three different possible outcomes of systems of linear equations by having two cars (robots) start at different times and move at different speeds. Additionally, students work in teams to complete sample RoboPlay Competition challenges either with physical robots or in RoboSim.

The robot function **robot.drivexyTo()** found in the RoboSim X-Y coordinate system, is an effective way for students to discover that a graph of a linear equation is the set of its solutions plotted on a Cartesian plane. Students working in pairs are given code that takes a line with positive slope and plots its solutions for the x-values from 0 to 10 on the RoboSim X-Y coordinate plane. Once this is done, the code moves the simulated robot through the same points using robot function **robot.drivexyTo()** in the RoboSim X-Y coordinate system. Once they get the code to work, students run the code with and without the tracing functionality.

Unit Four: **Quadratic Equations - Playing with Quads**

In this unit, students apply previously learned concepts about solving equations, functions, and computer programming to construct knowledge about solving quadratic functions and real life applications of these functions. The key tasks direct students through the concepts of multiplying binomials, understanding quadratic functions as the product of two linear factors, evaluating quadratics, methods of solving quadratic equations, graphing quadratic equations and applications of quadratic equations to solve problems involving projectiles. When working on math concepts for each task, students use Ch command window to evaluate quadratic expressions and calculate the coordinates of the vertex and the solutions (x-intercepts) of a quadratic function. Also, students run a utility program in Ch to factor multiple quadratic equations and to modify an existing program to calculate the vertex and solutions of a new equation. Students use their knowledge to construct equations, apply and synthesize their knowledge of programming with quadratic functions, and operate robots with precision. In this process, students apply Standards of Mathematical Practice by looking for and making use of programming and mathematical structure while expressing regularity in repeated reasoning.

In one task, students make predictions of how changes in the values of a, b, and c of a quadratic equation in standard form will affect the graph of the parabola and assess the accuracy of those predictions. Students use the member functions of the class **CPlot** to plot given quadratic functions. Prior to plotting each function, students will make predictions about the location of the vertex, direction of the opening, width of the parabola, and the domain and range of the function. Students will record their predictions before plotting the functions and note whether or not they were accurate. Students then work in groups to

draw conclusions regarding how the values of a, b, and c of a quadratic equation in standard form affect the graph of a parabola.

Unit Five: **Special Functions: Piecewise and Absolute-Value**

In this unit, students are introduced to three new types of functions: piecewise, step, and absolute-value functions. Students build upon their knowledge of lines, functions, and programming and robots to develop a deeper understanding of the new types of functions. Throughout the tasks in this unit, students are actively engaged in using computing to learn about piecewise, step, and absolute-value functions. Students model real-life situations with these types of functions, write programs in Ch to generate graphs and tables, and analyze and generalize the steps to completing each task. Students create a piecewise function to outline the shapes of icicles given on a photograph. In addition, students use an absolute-value function to model the rate at which a rainstorm rains and analyze and interpret components of the graph in terms of the context. Students develop a deeper understanding of transformations on functions through modeling different rainstorms with absolute-value functions. Students model cell phone data plans using a step function and analyze and interpret components of the graph in terms of the context.

One task composes absolute-value function with the floor function to generate a step function. Each student receives a printout of the codes of a Ch program that generates the graph of the function, $f(x)=abs(floor(x))$, or $f(x) = ||\_x\_||$, with the domain of -6 to 6 and a range of -1 to 7. Students copy the codes into ChIDE and analyze the graph generated by their program. In a short essay, students answer questions addressing which component of the function generates all those line segments, and which component generates the v-shape of the graph.

Unit Six: **Probability and Statistical Data Analysis**

In Unit Six, students reason abstractly and quantitatively to create plots with a title, labels, and specific points using member functions **plot.title(), plot.label(),** and **plot.point(),** respectively. Students make use of copying, pasting, and printing the displayed plot. Additionally, students informally fit a straight line to a scatter plot and find the trend line for the data. Students build upon probability concepts learned in the middle grades to compute and interpret permutations, combinations, and conditional probabilities through computer programming and robotics. Predicting the probability of an event occurring by observing the relative frequency of the event occurring over many trials, students develop a model from those observations using a while-loop. Also, using single-variable statistical measures like mean, median, and standard deviation, students summarize, represent and interpret data. Additionally, students use simple linear regression and residuals to analyze two-variable data. The data can also be interpreted using statistical models like scatter plots, dot plots, bar graphs, histograms, and Box-and-Whisker plots.

For one task, students plot points with the x- and y- values given on a chart to determine the relationship between the points and to form a linear equation. Additionally, students need to be in groups of 2-4 with 2 robots per group. Students will create a 4 by 4 grid and place the two robots at teacher-defined (x,y) coordinates. The goal of this activity is to have the robots be aligned in a straight line with a slope of 1 when they finish moving. Students apply their understanding of linear relationships by moving the robots in a straight line.

(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 Common Core Mathmatics with C/C++ Interpreter Ch for Algebra 1

Edition:

Publication Date: June 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.

> Title: Learning Robot Programming with Linkbot for the Absolute Beginner
>
> Edition: 6th
>
> Publication Date: June 2016
>
> Publisher: UC Davis C-STEM Center
>
> Author(s): Harry H. Cheng
>
> URL Resource(s): http://c-stem.ucdavis.edu

[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)

x_____ ("c") – Mathematics

_____ Algebra 1; Yr 1 of 2

_____ Algebra 1; Yr 2 of 2

x ____ 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

_____ ("g") – College-Preparatory Elective

_____ History / Social Science

_____ English

_____ 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