INTEGRATED STEM

I3 LEARNING BY MAKING, SONOMA STATE UNIVERSITY

BASIC COURSE INFORMATION

Title:	Integrated STEM
Length of course:	Full Year
Subject area:	Laboratory Science ("d") / Interdisciplinary Sciences
Integrated (Academics / CTE)?	No
Grade levels:	9th, 10th, 11th, 12th
UC honors designation?	No
Course learning environment:	Classroom Based

COURSE OVERVIEW

The Integrated STEM course fuses mathematical skill-building and computational thinking applied to real-world scientific problems where solutions are constructed by students and instructors working together. This course includes **80% hands-on teacher supervised lab activities** and 20% skill-building instructional time. **The lab activities include explicit information on safety and regular warnings on the dangers of electric shock.** Students undertake personally-relevant investigations in chemistry and physics, using Logo, a programming language, to read sensors and to obtain and analyze data. They will develop and use models, construct explanations and arguments from experimental evidence, and report and communicate their results to peers and instructors. This course has been specifically developed to implement Next Generation Science Standards in the high school classroom. As such, Disciplinary Core Ideas are integrated with Crosscutting Concepts and presented in the context of Science and Engineering design practices.

Prerequisites:
Algebra I (Recommended)
Co-requisites:
Algebra I (Required)

COURSE CONTENT:

INTRODUCTION AND OVERVIEW

This course builds basic skills in electronics, programming, data acquisition and analysis, constructing explanations and making simple models. The curriculum consists of a library of base experiments with suggested redesigns centered around real-world problems. Students will explore interactions between light and matter, chemical reactions, energy and its uses, and the forces that govern our physical universe. For each major experiment, students are engaged in the **complete life cycle of an experiment** that spans all 8 NGSS Science and Engineering Practices:

1. Asking questions (for science) and defining problems (for engineering) – All Units
2. Developing and using models – All Units
3. Planning and carrying out investigations – All Units
4. Analyzing and interpreting data – All Units
5. Using mathematics and computational thinking – All Units
6. Constructing explanations (for science) and designing solutions (for engineering) – All Units
7. Engaging in argument from evidence – All Units
8. Obtaining, evaluating, and communicating information – All Units

UNIT 1: WELCOME TO STEM

INTRODUCTION TO THE COURSE AND COMPUTATIONAL TOOLS

The unit focuses on the fundamentals of scientific inquiry, including communications skills, working in scientific teams as well as the scientific method. Students are presented with problems that require them to work together, communicate strategies, work within specific design constraints, and overcome strategic communication barriers. Students must use mathematical and computational thinking to construct explanations and design solutions for each problem. The unit provides students with the fundamental skills necessary to design and conduct team-driven, inquiry-based experiments throughout the course. The teacher utilizes student-driven learning by having the computers set up as they enter the classroom and simply asks the class to explore the functionality of the code. Students brainstorm to figure out commands that Logo recognizes. As students discover the commands that Logo is responsive to, the teacher creates a class list to document these commands. As students enter in lengthy, multi-step commands, the teacher introduces the concept of a "word" of computer code that encompasses multiple movement commands. A "word" has the ability to function as a continuous loop through the additional command of "repeat" given before the word.

Key Assignment: Turtle Art

In small lab groups, students will create original Turtle Art with the TurtleLogo programming environment. This assignment includes specific programming tasks such as using loops, variables, and functions. Student programs must also demonstrate an understanding of the mathematical properties of various geometric shapes. At the end of this unit, each group will present their Turtle Art to the class and share their TurtleLogo programs.

UNIT 2: GO WITH THE ELECTRON FLOW

INVESTIGATING ENERGY AND CHARGE IN ELECTRONIC CIRCUITS

The unit focuses on understanding fundamental properties of electricity and learning how to use the technology that will be fundamental to conducting labs and experiments throughout the course. This includes working hands-on with circuitry, wiring, electronic components digital multi-meters and connecting these circuits to the BasicBoard microcontrollers that will be used throughout the course. Students must use mathematical and computational thinking to construct explanations and design solutions for problems presented in this unit. Students will plan and carry out investigations around voltage, current, resistance and will be able to analyze and interpret the data from the readings and draw conclusions about Ohm's law.

Key Assignment: **Coded Communications**

In small lab groups, students will build and modify simple circuits using LED lights, resistors, the BasicBoard. The students will be assessed on their ability to write a Morse Code communication Logo program to send and receive coded messages via blinking LEDs.

UNIT 3: SENSORS

INVESTIGATING THE STRUCTURE AND FUNCTION OF ELECTRONIC SENSORS

Unit 3 includes base laboratory setups for analog light sensors and analog temperature sensors. Students must use mathematical and computational thinking to construct explanations and design solutions for problems presented in this unit. Students will use experimental observations to describe the structure and function of each sensor. They will test and refine logo programs to explore the mathematical relationship between analog sensor readings and data recorded by the BasicBoard.

Key Assignment: Building a Night Light

These assessments will bring together everything students have learned about Logo programming by creating a physical product that requires the use of loops and logic statements. The students are provided with a Learning by Making BasicBoard connected to an analog light sensor and an LED. Through teacher guided instructions, students learn how to interpret light sensor readings and interact with the code. They must then write the code and test it with their apparatus.

EXPERIMENT UNITS

To be completed in any order

EXPLORE THE PHYSICAL WORLD

Students will synthesize all the skills and practices that they have learned throughout the first three units. They will design their own hardware, software, and data analysis techniques to test a hypothesis they have put forth based on a series of simple starter experiments.

Students will summarize their individualized experiments and present their hypotheses and results to their peers and instructor. They will discuss experimental design flaws and successes and present an argument based upon the evidence that they have collected as to the validity of their hypotheses. They will construct explanations as part of the comparison of their predicted results to the actual measurements, analyze problems with their experimental implementation and discuss methods that could be used to improve the experiment in the future. Students will create the presentations, including schematics of their design, explanations of the computer code they generated to run the experiment, calibrate, acquire, analyze and display the data. They will also present the resulting plots and simulations.

Starter Experiment Library

Absorption	Investigate how light energy is absorbed by different materials and converted into heat.
Evaporation	Investigate temperature changes as water evaporates from an object.
Exothermic Reaction	Investigate results of an exothermic chemical reaction between de-icing salt and water.
Microbial Fuel Cell	Build, modify, and test a device which uses microbes to generate power.
Heat Diffusion	Investigate how energy from a heat lamp diffuses through a large tub of sand.