CNM Ingenuity, Inc.

**COURSE SYLLABUS**
**June 7, 2021 – August 13, 2021**

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| **Course Name:** | **IOT Coding and Product Design Bootcamp** | | **Lumens Class ID:** | **TBD** |
| **Class Day(s):** | **Monday - Friday** | **Class Location:** | **FUSE Makerspace** | |
| **Class Time:** | **8:00am – 5:00pm** | | | |
| **Pre-requisite:** | **(none)** | | | |
| **Instructor:** | **Brian Rashap, Ph.D.** | | | |
| **Web Address:** | **http://deepdivecoding.com/iot** | | | |

## *Texts & Supplies*

1. **Textbooks: not required for this course.**
2. **Participant Guide: Students will need to participate in class and complete projects on-time.**
3. **Supplies: Students need to have access to a laptop computer (Windows, Mac, or Linux) that they will use every class session.**

## *Course Description*

Today, we see the proliferation of the Internet of Things (smart, connected devices) into all facets of society. We are entering the age of advanced manufacturing, what is being referred to as Industry 4.0, where predictive analytics, generative design, advanced materials, ubiquitous sensors, and automation/robotics is revolutionizing industries. Where we live, what started out as smart thermostat has become a connected home complete with robotic vacuums, connected appliances, smart security systems, and voice assistants. Our daily routines outside the home will also be revolutionized as the connected city helps us navigate traffic, find parking, optimize public transportation, improve air quality, reduce noise, and enhance public safety. From wearables to autonomous automobiles, technology is impacting every aspect of our lives. Behind all of this is the Internet of Things, low cost yet powerful compute capability, wirelessly connected to each other and the Cloud, and able to sense/influence the environments where we work and live. It is estimated that there will be 1 trillion connected devices by 2035. That is more than 100 smart devices for every person on earth.

The IOT Coding and Product Design Bootcamp will teach students the fundamentals of creating and coding smart connected devices built around low power computer chips. Starting with learning the components needed to build a smart lighting controller, working on devices for smart cities and/or smart manufacturing, and progressing through an original group design projects, students will be exposed to the fundamentals of circuit design, coding, and integration that will accelerate them towards careers in industries that build and/or use IoT devices.

## *Student Learning Outcomes*

Upon successful completion of the course the participant will be able to accomplish the following:

A. Apply structured coding techniques to the development and implementation of code for micro-controllers using C++. This includes the uses of data types, variables, operators, control statements, functions, arrays, and structures. Students will learn how to utilize object-oriented programming to implement advanced functionality.

B. Application of electronics and circuit design to enable sensors, actuators, and micro-controllers to interact with people and the surrounding environment. This includes the use of RC-circuits, switches, basic CMOS logic

components, relays, and displays. Students will learn to prototype via breadboard, develop circuit schematic, and layout printed circuit boards. Students will also develop a demonstrated proficiency in soldering.

C. Use of critical thinking and structured problem solving to develop devices and programming code that enable machine-human, machine-environment, and machine-machine interaction through the use object-oriented programming blocks to implement wide variety of functionality for smart, connected applications.

D. Demonstrate the ability to uunderstand, code, and utilize various microcontroller interfaces - analog, digital binary, serial, SPI, I2C, and CAN. This includes a demonstrated understanding of the strengths and deficiencies of various interfacing schemes and the selection of the most appropriate protocol for an application.

E. Utilize additive manufacturing (3D printing) to design supports and enclosures for IOT devices. This will include experience with a basic CAD system to develop a computer model of the desired device and the process of creating an actual device through the use a 3D printing process.

F. Develop collaboration, teamwork, and communication skills necessarily to complete both an individual and group-based product design of an original IoT devices. Students will be exposed to several guest lectures throughout the bootcamp that will expose the students to real-world problems that can be solved by deploying IoT.

## *Attendance/Tardy/Withdrawal/Drop Policies*

The participant will be awarded an attendance grade based on the amount of time he or she is in class.

In the event CNM is on a delayed schedule, classes meeting prior to the announced start time will not meet. Classes scheduled at or after the announced start time will meet.

It is the responsibility of the participants to cancel his/her class registration or request transfer into another class offering at least 48 hours prior to the first class.

## *Grading*

**Letter grades are not awarded for CNM Ingenuity's** non-credit classes. A final grade of Complete, Incomplete or No Show will appear on the participant's CNM Ingenuity transcript.

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|---|---|
| Complete | Participant attended all class contact hours |
| Incomplete | Participant attended some, but not all class contact hours |
| No Show | Participant registered, but did not attend the class |

## *Course Codes & Policies*

**Student Behavior:**

As a member of this classroom, participants are responsible for understanding and adhering to the CNM codes and policies that govern and prescribe acceptable student behavior. The codes and policies of this course are governed by the Academic Policies found on the Student Code of Conduct accessed at:

https://www.cnm.edu/depts/dean-of-students/student-code-of-conduct

## *Student Resources/Advisement/Graduation*

A CNM Achievement Coach is available to all CNM students and participants. The Achievement Coach's main job is to help students find the answers to questions concerning classes and issues involving college and life. The Achievement Coach helps with the following: program and course information, campus and community support, balancing school, family and work, life changes and obstacles. Ask your Instructor or Program Coordinator for more information about making an appointment with an Achievement Coach.

## *Tentative Class Schedule*

**Syllabus & Class Schedule:** The syllabus and class schedule are subject to change by the instructor. Changes will be made with as much advance notice as possible.

**Prework**

In order to prepare the students for the projects during the Bootcamp, students will need to complete one of two FUSE Makerspace workshops prior to the Bootcamp beginning:

- Introduction to Woodworking (3 hours) or
- Introduction to Metal Working (3 hours)

Several classes to choose from will be scheduled in the weeks leading up to the bootcamp. See https://fusemakerspace.org/workshops/ for a complete list of FUSE Makerspace classes.

Note - Students will have a complementary membership to the FUSE Makerspace during the Bootcamp. They are encouraged to learn to utilize other equipment at the Makerspace. Workshops range in price from $49 to $69 each.

**Weeks 1-4 description**

Students will learn basic electronic circuit design, programming of an ARM-based micro-controller using C/C++ (via the Arduino IDE), soldering, and basic micro-controller coding. Using a smart light switch as an educational vehicle, students will learn how to interface peripherals to the micro-controller in order to sense conditions from and manipulate the surrounding environment. Students will learn coding skills that will allow them to implement various data structures, utilize input/output interfaces, build functionality through object-oriented blocks, store data to removable memory, and communicating via ethernet to other IoT devices. During the first segment of the bootcamp, students will also be trained on proper soldering techniques and learn to use both 3D printers and laser cutters.

**Weeks 5-7 description**

Students will expand their knowledge of micro-controllers with the introduction of an industrial IoT platform - the Particle Argon IoT Controller and the Visual Studio Code IDE. They will further explore connectivity using wireless communications and mesh networks. Students will be introduced to both Industry 4.0 and Smart City infrastructure and use cases, as well as get hands-on experience implementing solutions in these two areas. Students will learn to send (publish) data to and get (subscribe to) data from Cloud in order to increase device functionality. They will complete an individual design project that interfaces a variety of IoT sensors and actuators to design solutions for a real-world issue.

**Weeks 8-10 description**

Students will identify a new that can be addressed by a smart device. Working in small groups, the students will design, code, produce, and demonstrate an IoT device that addresses the customer's need.

## Course Calendar: (Subject to Change)

| Date | Topic/Section | Projects Implemented |
|---|---|---|
| Week 1 | • Introduction to Arduino IDE, Teensy specific packages, and Fritzing<br>• Introduction to C/C++ syntax<br>• Soldering training<br>• Circuit basics<br>• Flowcharting<br>• Digital / Analog – Input / Output<br>• Functions and Local Variables<br>• Object Oriented Programming<br>• Header files and libraries.<br>• User Input / User Experience<br>• Intro to 3D Modeling | • L01_HelloWorld<br>• L02_HelloLED<br>• L03_Buttons<br>• Traffic Light<br>• L04_oneButton<br>• F01_FlowerPot (3D) |
| Week 2 | • Arrays<br>• Daisy chained RGB LEDs | • L05_Neopixel<br>• L06_Encoder |

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| | • Encoders<br>• Serial Communications (SPI, I2C)<br>• Read/Write SD Card<br>• Ethernet Communications<br>• 3D Printing (filament) | • L07_SPI (uSD Card)<br>• L08_Ethernet<br>• WEMO Smart Outlets<br>• F02_Personalized Lego (3D) |
| Week 3 | • Servo Motors<br>• KeyPad Inputs<br>• Environmental Sensors<br>• OLED Displays<br>• Reverse Engineering 3D Part<br>• 3D Printing (resin) | • L09_Servo (+ 3D Part)<br>• L10_I2C (OLED, BME280)<br>• L11_Hue<br>• F03_Slip Case (3D) |
| Week 4 | • Product Integration<br>• Laser Cutting<br>• Hackster.io<br>• Design Sprint Methodology for Rapid Prototyping | • Smart Room Controller<br>• Laser Cut Box<br>• Simon Game (Optional) |
| Week 5 | • Particle Argon Microcontroller and the Visual Studio Code IDE<br>• Frequency Filters<br>• Intro to Semiconductors<br>• Bipolar Transistors<br>• Op Amps<br>• Voltage Shifting<br>• Relays and Solenoids<br>• Wifi Communication / MQTT<br>• Adafruit IO Publish and Subscribe<br>• Interfacing Smart Sensors to Cloud | • L12_HelloCloud<br>• L13_Semiconductor(Filters, Amps)<br>• L14_Soil Moisture (Smart Plant Watering System)<br>• F04_Fan Blade / Water Wheel (3D) |
| Week 6 | • Bitwise Operations<br>• EEPROMs<br>• Interrupts<br>• Smart Manufacturing<br>• Capstone Project – selection/scoping | • L15_BEI<br>  ○ Bit shifting<br>  ○ EEPROMs<br>  ○ Interrupts<br>• Smart Mfg (Power / Vibration)<br>• F05_ESP32-CAM (3D)<br>• Cisco CKC / Atlantis |
| Week 7 - 8 | • Accessing specific registers<br>• Bit Shifting, Binary Math<br>• Stepper Motors<br>• Accelerometers/Gyroscopes<br>• Piezoelectric / Vibration<br>• Hall Effect Sensors<br>• Load Cell / Strain Gauge | • L16_Motion<br>  ○ Stepper Motors<br>  ○ Accelerometers<br>  ○ Rotation<br>  ○ Vibration Monitoring<br>  ○ Strain Gauges<br>• F06_Microcontroller Enclosure (3D)<br>• Field work at FUSE / City of ABQ Smart City testing area |
| Week 9 - 10 | • Using Pointers, STRUCT datatype, doubly linked lists.<br>• Develop, Package, and Test Smart Sensors<br>• Group Design Projects | • Capstone Project |

### *Guest Speakers*

Each week, the class will have a guest speaker that will expose the students to various IoT skills, careers, and opportunities. Speakers will span many fields including:

- Immersive Entertainment
- Sustainability and IoT for facilities
- City of ABQ Smart Cities Efforts
- Smart Manufacturing
- IoT for Healthcare
- Robotics
- IoT on the Moon
- Intellectual Property and IoT entrepreneurship

### *Grading criteria*

- Successful completion of individual "learning" projects
- Implementation of an individual smart sensing project.
- Group project design, development, packaging, and presentation

### *Electronic Devices in Class*

All cellular telephones should be turned off or switched to silent or vibrate mode