Purpose: The modest purpose of this class is to change your life. If the plan is successful, you will be empowered to understand, investigate, and appreciate computers even more than you do presently. This course is centered around small, inexpensive but powerful computers which have moved our interactions with computers off the desktop and into cars, phones, watches, your contact lenses, and probably inside you eventually. Right now the most exciting wave of rapidly growing interest in computing centers about small devices which interact with humans in ways not possible even ten years ago. The falling ratio of price to computing power means you can afford to explore a number of such systems for a very modest investment.

This is an experimental class both in the way it is taught and in the content. I am not going to deliver numerous lectures on content for you to write down and commit to short term memory for a future exam. The core material will be outlined for context but you will spend most of your time designing, coding, making, breaking, debugging, repairing, and demonstrating embedded computers and circuits. There is NOT a fixed set of facts to know. This is about absorbing knowledge you need to progress. After this class you will have sufficient experience with embedded devices that you could begin designing, building, and coding those same devices for others to use and make a good income doing just that. Most importantly, you will see that embedded computers are devices which can be understood and programmed, even at the very technical level, by reading the appropriate documentation, being organized in your study, using the right tools, and just ‘trying things out’, otherwise known as experimenting. So, let’s try things out!

We will be spending at least one class per week in a lab setting working on the practical aspects of electronic circuits, devices, circuit building, microcontrollers, digital signals, timing, sensors, and so on. I do not assume you know ANYTHING about electricity or electrical circuits right now. You may assume you will know quite a bit more when this class is over.

Class Title: This course is titled Embedded Computing because we are interested in devices and systems which are designed to function in mobile, remote, and non-tethered environments where these devices figuratively “swim” around us. A short list of embedded systems in roughly chronological order might be something like this: aircraft autopilots, satellite/spaceship controllers, TV remote controls, digital watches, smart thermostats, heart pacemakers, mobile robots (especially the Mars rovers), Segway personal vehicles, automobile GPS systems, cell phones, insulin pumps, Google Glass, and now literally dozens of others.

Class Format: We will begin with a mix of lectures, demonstrations, and discussion with lab sessions about once a week. This lecture/lab distinction will soon blur to a great extent. Much of our time in later weeks will be spent in the lab putting things together, experimenting with circuits and devices, programming, and testing code. This is a class where the theory meets practice, lots of practice. I believe that we cannot fully understand the fascinating simplicity/complexity of computers without actually touching the components at some stage. Even better is to design and build your very own embedded system for everyday use. You should plan on being VERY ENGAGED in this class. You cannot simply take some notes, study the book
and your notes before the exam, and expect to do well in this class. It won’t happen that way.

**Reading Materials:** We will be using *Arduino Cookbook*, a fairly comprehensive book on Arduino programming structured as small recipes for doing various things with Arduino. You should page through the entire text just so you know what is possible using Arduino, how to improve on the basic recipes, etc.

Additional reading material will be provided by handouts from technical journals, manufacturer data sheets, Circuit Cellar, and other trade journals. Again, this is not a course where there exists a small collection of discrete facts in some book which you are responsible for learning in order to please me and/or receive a good grade. You will need to synthesize the course materials in order to understand basic electronics, gates, Boolean logic, computer organization, some elementary robotics, the Wiring and Processing languages, PCB assembly, and other topics. Be ready to think about how it all fits together instead of just memorizing facts. The more you put into the course, the more you get out of it.

**Homework:** Homework assignments, usually just a few questions, will be assigned regularly in class. Information needed to answer the homework problems will be covered during the class conversations and in the assigned readings. I will not collect the homework for grading but I will randomly ask different people in class to very briefly present answers to homework in class. Don’t stress over this – it is a chance to show off what you know in a supportive environment where everyone is in the process of learning the material. You will need to come to class having worked on the homework.

**Lab reports:** You will be required to create a writeup for labs in the initial part of the class. Each lab team of two students is responsible for writing up a description of your lab activities, results, charts, tables, schematics, etc. Labs are typically on Monday with lab reports due Friday at the start of class. I will provide more details of what is required on the labs themselves.

**Attendance:** I will take attendance at every class and lab. Missing more than three classes/labs will decrease your final course grade by at least one letter grade. The more absences, the more your grade decreases.

**Quizzes:** There will be a short 15 minute quiz every Friday in class. These will cover the current homework and lab material we are working on that week. Recognizing that emergencies and illnesses happen to us all, I will drop your lowest quiz grade when computing final grades.

**Exam:** There is one midterm exam which covers the more rote aspects of computer architecture and embedded computing such as electronic components, simple circuits, Arduino sketches, programming exercises, etc. The midterm exam is **Friday February 26th in class**. There is no final exam.

**Projects:** You will be designing, constructing and programming various devices this term which are intended to perform some interesting or useful task. This will be done sometimes in small teams and others will be individual projects. Each project will require a write-up on what you did, how well it worked, and suggested improvements.

The list of potential projects is VERY large and will require you to be thinking ahead so we can acquire any necessary materials in a timely fashion. I will post lists of potential projects along with many links to web sites for project ideas, and print articles as well. Of course, I encourage you to develop your own project ideas as well. Project outlines will be distributed prior to each project cycle.

**Project Demonstrations:** The final exam in this class has been replaced by a demonstration of the various projects you design and build during the class. You may consider this a kind of Embedded Systems Showcase where the HWS community gets to see some of the cool stuff you did this term. I will give a detailed description of the format and content in advance of this event. This presentation will take place on
Friday May 6th in Scandling Center so DO NOT make travel plans before checking this date!

**Class Materials:** You will be provided with almost all the materials you need throughout the term but there are some things that you must supply. First, you need to buy an Arduino microcontroller, UNO, METRO, Esploras are okay options, from one of the suppliers such as Adafruit, Sparkfun, Radio Shack, etc. Arduino is a very capable device for learning about sensors which you can use in a number of projects. I have additional Arduinos, Raspberry Pi, BeagleBone, etc computers for more advanced projects.

If you have an iPhone/iPad or any Android OS phone or tablet, this can be your platform for some programming assignments in the latter part of the class. If you don’t own any of these platforms, I have some Android tablets available for you to use this semester.

I will provide all the basic tools to use for circuit construction and project building but if you wish to purchase your own hand tools feel free to do so. You will be using small diagonal cutters, small needle-nose pliers, wire strippers, and a very low wattage soldering iron. You can obtain your own diagonal cutters, pliers, and wire strippers from local hardware stores. The very small soldering irons are a bit more difficult to obtain locally but there are lots of catalogs on the web offering every tool you will ever need and more.

**Programming:** We will be coding in Arduino/C/C++, Wiring, Processing, and either Objective C (iPhone/iPod Touch/iPad) or Java/Android for the projects I have planned. I will provide some primers for several of these languages but you will need to put in some quality time learning to write simple programs as you create your projects. Background in Java is enough to get started.

**Grading:** Your grade will be determined by all your activities in the class throughout the term. There are approximately 12 quizzes worth 10 points each, about 10 formal labs each worth 25 points, a midterm exam worth 100 points, 4-6 projects each worth 25-50 points, a final presentation/project worth 50 points, and your attendance/participation worth 25 points. I will assign grades on the percentage of these points you amass during the term.

**Coda:** Why are we doing all this in just one fast-paced course? Again, the hope is to change your life. You may choose to put your completed projects on the shelf and never touch them after this class is over but I hope some of you will use this experience as a way to start designing and enjoying computing/electronics/programming in a much more empowered and personal manner. The people at JPL and NASA who sent Curiosity, Opportunity, and Spirit (look them up if needed!) to Mars began their own computer science and engineering careers with projects just like ours! Welcome.

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**Note from CTL:** At Hobart and William Smith Colleges, we encourage you to learn collaboratively and to seek the resources that will enable you to succeed. The Center for Teaching and Learning (CTL) is one of those resources: CTL programs and staff help you engage with your learning, accomplish the tasks before you, enhance your thinking and skills, and empower you to do your best. Resources at CTL are many: Study Mentors help you find your time and manage your responsibilities, Writing Fellows help you think well on paper, and professional staff help you assess academic needs.