Introduction to Electronics and Physical Computing for the Arts
Course Number: DANM 133
Instructor: Gene A. Felice II – www.genefelice.com
Course Website: www.genefelice.com/danm133
2nd Session Summer 2013 Syllabus
Classrooms: Art Building E133 for lab
& Digital Arts Research Center (DARC) 206 for lecture & lessons.
Instructor Contact: gfelice@ucsc.edu
Office Hours: by appointment

updated: 8/22/13

Course Description:
Introduction to Electronics and Physical Computing for the Arts is both an introduction to building electronic artwork using analog electronics and the open-source Arduino platform, as well as an examination of this technology's role in contemporary digital art. Through hands-on tutorials, students will experiment with building electronic circuits and coding in the Arduino programming environment to create an interactive art project that illustrates key principles learned in the course. Students will be introduced to components such as sensors, switches, motors, and lights, as well as technical principals such as electricity, circuits, soldering, and the use of testing equipment in a workshop setting. In addition to building circuits, we will explore how artists use these devices to gather data and produce a variety of output through presentation and analysis of digital artworks.
Laptops are encouraged, but we will also have access to the computers in E133.

A Materials Fee of at least $75 per student should be charged (covers costs of electronics, tools, microcontrollers, materials and final project budgets).

Class Structure / Goals:
Class will meet in E133 each day and will be split between individual and group lab time working with electronic equipment for lectures & class discussions in DARC 206. Homework assignments will include outside readings and review of artist work, software tutorials & technical documents with reflections / responses to be written for each. Class content will include software demos, development of concept, aesthetics, techniques and processes used in electronic based arts. The method of instruction will include lectures, demos, and video as well as in and out of class assignments.

Class Schedule:
Class #1:
Intros:
- Attendance & Introductions to each other (round: who, dept. experience, interests in class) 20 min.
- Give Out Door Codes & test 10 min.
- Review of Syllabus 30 min.
- Introduction to instructor (focused on interactive works: ADSR, Mini-Moogseum, SDOP, P2, The Smoker) 1 hr.

Break (10 min)

- Brief history of DANM and tour of DARC. 30 min.
- Moog Documentary 30 min.

LUNCH

Review & Discuss Early Works in Art & Technology: 1 hr.

- Nam June Paik
- Billy Kluever's Experiments in Art and Technology (1966)
- LACMA Art & Technology Show (1969-1970)
- Chris Burden: Prelude to 220 or 110 (1971)
- Bill Parker: A.M. Lightening, P.L. B.B. (1974)
- Walter de Maria Lightening Field (1977)

10 min. break

- DC electricity basics: Polarity, Grounding, Wiring, Resistance 30 min.
- Tools Session: shared tools, types of tools, tool safety! 20 min.
- Reverse Engineering session: Break into random groups of 3 and take apart a randomly chosen machine and inventory parts (motors, switches, motor mechanisms, buttons, etc). 1 hr.

Homework:

***Read** the first six "vehicles" (mini-chapters) of "Vehicles" by Valentino Braitenberg & Essential Electricity PDF by Peter Elsea. PDF versions of texts are available to for download from the class resources page of E-commons.*

***Write** a 500 word response / reflection based on the readings and upload to your drop box on E-commons.*

Class #2:

- Discussion of first 6 vehicles of "Vehicles" and "Essential Electricity". 30 min.
- Intro to Basic Electronics: 1 hr. 30 min. (Steven)
    - Presentation of DC electronics and principles, including:
    - Ohms law
    - Resistors (color codes)
    - Online / Apps for resistor color code apps
        - ♣ http://www.digikey.com/us/en/mkt/4-band-resistors.html
    - Breadboards, PCB's & Jumpers
    - Diodes & LED's
    - Batteries & Capacitors

10 min. break

- Interpreting schematics & data sheets (reading & creating): 50 min.
    - Intro to Fritzing & Hand Drawn circuit diagrams

LUNCH

- A continued review of Early Works in Art & Technology: 1 hr.
    - Robert Rauchenberg: Open Score (1966) http://www.fondation-langlois.org/html/e/page.php?NumPage=642
    - Brion Gyson – Burroughs Cut Ups http://www.youtube.com/watch?v=Rc2yU7OUMcI&feature=share
    - Bruce Naumann
    - Bill Viola http://www.oberlin.edu/images/Art067/Art067.html
    - Ann Hamilton
    - Mariko Mori
    - Gail Wight

    - Paul DeMarinis

10 min. break

- An Introduction to 555 or Op Amp timing circuits. 20 min. (Steven)
- Make a flashing or throbbing LED circuit with a transistor-based circuit on a breadboard 1.5 hrs.

Homework:
Design a simple circuit, hand drawn or in Fritzing (http://fritzing.org/download/)
***Read:** "Wiring for Contraptions" by Peter Elsea and Vehicles 7 through 14 in "Vehicles" by Valentino Braitenberg, PDF files are available on E-commons class resource page.*
***Write** a 500 word response / reflection based on the reading and upload to your drop box on E-commons.*

Class #3:

- Discussion & Questions about "Electronics for Contraptions" reading by Peter Elsea and vehicles 7 through 14 from Valentino Braitenberg's "Vehicles" 20 min.
- Review each student's circuit diagram's 40 min.
- Review Syllabus update!
- Thursday's Field Trip: Who has bikes?
- Final Projects theme review: Ocean ecology & sustainability: 30 min.
    - Discuss available budget & overall timeline
    - Announce teams

10 min. break

- Soldering workshop: students will learn how to safely use tools such as: 1 hr 30 min.
    - multi-meter
    - Wire (solid core vs. stranded)
    - Connectors (DC, AC, molex, etc.)
    - helping hands
    - soldering iron basics:
        - ♣ sand surfaces to clean
        - ♣ use flux if needed (don't have flux core solder)
        - ♣ 600 to 800 degrees
        - ♣ Clean iron on sponge.
        - ♣ Touch iron tip to both parts of joint.
        - ♣ Count to 3 to 10, depending on mass of joint.
        - ♣ Touch solder to joint-- it should melt instantly.
        - ♣ Pull solder away, leaving a drop on the joint.
        - ♣ Remove iron.
        - ♣ Work should not be disturbed until solder turns gray.
    - Solder Wick:
        - ♣ lay the wick across the joint and heat the joint through the wick, most of the
        - ♣ solder will be absorbed by the wick.
    - Practice tining & soldering wire, resistors and possibly a switch to form a simple LED circuit.
    - http://www.evilmadscientist.com/2012/resistors-for-leds/
    - After assembly, students will test the continuity of their circuits with a multi-meter

LUNCH BREAK

- Review artists within the final project theme: 1 hr.
  - David Bowen http://www.dwbowen.com/portfolio.html
  - Phillips Microbial Home: http://www.design.philips.com/about/design/designportfolio/design_futures/microbial_home.page
  - Ken Rinaldo (fish, spider & autopoeisis)
  - Amy Youngs (compost & farm fountain)
  - Phillip Ross
- Intro to vehicles / creatures in-class project for the afternoon: 15 min.
  - http://modes.io/hacktivism-spasticrobots-2/
  - Biomimicry inspiration, spastic robots
  - Motors: polarity = forward / back
  - Transistors:
    - ♣ collector, emitter & base (check data sheet)
  - Solar Panels vs. batteries
  - Capacitors:
    - ♣ pf (picofarads) uf (microfarads)
    - ♣ stripe is negative!
- 10 min. break
- FLED SOLAR ENGINE PROJECT LAB TIME: 1.5 hrs
  - Break into groups of 3 (random picks)
  - Pick parts to work with (1 motor, 1 solar panel, 1 form of locomotion (wheel, springs, flagella, etc.) & alternative materials)

Homework:
Read: *"Electronics for Contraptions" and Essential Arduino by Peter Elsea. PDF files are available on E-commons class resource page.*
Write: *a 500 word response / reflection of the reading and upload to your drop box on E-commons.*
Begin researching & thinking about final project ideas and begin sketches

Class #4:

- Discussion & Questions about "Electronics for Contraptions" & "Essential Arduino" readings by Peter Elsea. 20 min.
- Continue working on FLED SOLAR ENGINE Projects: 1.5 hrs.
  - Move from the breadboard to a fully soldered and heat shrinked unit
  - Test in the Sun & Make final tweaks

10 min. break

- Present final FLED SOLAR ENGINE projects to the class for critique. 1 hr.

LUNCH BREAK

- AFTERNOON FIELD TO MONTEREY BAY AQUARIUM RESEARCH EXT and possible the Seymour Long Marine Center. Everyone meet at center at 3pm!
  - Whole class brainstorming session for team projects on site or ocean side!

Homework:

- Research a digital art project that focuses on ecology or sustainability and write a 500 word description of the work from both art and technology points of view.
- Meet with teams to work on final project proposals, budgets & timelines. Final

project proposals should consist of a 1 page project description, sketches, timeline & budget (1 proposal per team).

Class #5:

- Final Project proposals, timeline, material list & budget due with final sketches:
  - Present to class for group critique 1hr.
- Intro to Arduino
  - Predecessors: TI Basic Stamp, PIC controllers: ran on basic language $100 each.
  - Arduino was developed by a pair of teachers, Massimo Banzi and David Cuartielles, at a short lived Italian Design school to be cheaper and easier than basic stamp.(http://spectrum.ieee.org/geek-life/hands-on/the-making-of-arduino/0)
  - Simple Computers that do simple tasks
    - ♣ Some people think of the entire Arduino board as a microcontroller, but this is inaccurate. The Arduino board actually is a specially designed circuit board for programming and prototyping with Atmel microcontrollers (ATmega328 $3 on digikey).
    - ♣ Mega and other versions image (also show Raspberry Pi)
  - Features: (see overview image)
    - ♣ Open Source: Shields & Accessories
    - ♣ Easy USB interface
    - ♣ Power management & voltage regulation (12 volts in, 5 or 3.5 volts output)
    - ♣ A 16mhz clock (not super fast but adequate for most jobs)
    - ♣ 32 KB of flash memory for storing your code.
    - ♣ 13 digital pins and 6 analog pins:
      - Input a bit (all pins).
      - Output a bit (all pins).
      - Output a control voltage via pulse width modulation (PWM) (6 pins)
      - Read a control voltage (six pins)
      - Produce a servo control signal (two pins)
    - ♣ An ICSP connector for bypassing the USB port and interfacing the Arduino directly as a serial device
    - ♣ An on-board LED attached to digital pin 13 for fast an easy debugging of code
    - ♣ a button to reset the program on the chip
  - Can use Arduino (C or C++) & Software Library called “Wiring” or Processing programming platforms (Java)
  - Review of the Arduino data sheet and digital & analog pins
  - Watch laser cutter session of protoboards being cut.
  - Assemble Arduino Protoboards

10 min. break

Tour of Music electronics lab (1:15pm)

LUNCH

- Discussion of Arduino's role in a variety of student based digital art & new media projects. 1 hr. min.
    - Smoker (http://genefelice.com/art/2000/08/03/the-smoker/)
    - Departure Points (http://genefelice.com/art/2002/06/01/departure-points-a-b-c/)
    - The Harrington Project (http://vimeo.com/49354640)
    - Shy (http://vimeo.com/65003387)
    - Doo Sung Yoo (http://www.youtube.com/user/yoodoos)
    - Fernando Orlena (http://vimeo.com/14106515)
    - Joshua Penrose (http://vimeo.com/7823924)
    - DXArts (http://vimeo.com/15784614)
    - DXArts (http://vimeo.com/20149711)
    - DXArts (http://www.youtube.com/watch?v=zj0IPd_s8mI)
    - Arduino Playground (http://playground.arduino.cc/projects/arduinoUsers)
    - Adafruit Student Projects (http://www.adafruit.com/blog/2012/09/19/my-students-first-arduino-projects/)
    - Water Light Graffiti (http://vimeo.com/47095462#)
    - Robot Fish (http://www.open-electronics.org/robofish-create-your-robot-fish-with-arduino/)
    - Robot Water Snake (http://www.instructables.com/id/Make-a-swimming-Robo-Snake/)

- Getting Started: Fundamentals for Arduino IDE (Integrated dev environment): 1 hr. (see "Intro-to-Arduino.pdf and "IntroArduinoBook" on class resources page)
    - Plugin Board via USB
        - ♣ IntroArduinoBook.pdf (pg. 16)
        - ♣ Tools > Boards (select uno)
        - ♣ Tools > Serial Port (/dev/tty.usbmodem [random numbers])
    - Run a sketch: Files > Examples>Blink
    - Serial monitor: Monitor / Debug tool (help to understand incoming data)
    - Digital In: (binary signal – basis of all computing)
        - ♣ On / Off
        - ♣ HIGH or LOW
        - ♣ 1 or 0
        - ♣ 5V or 0V.
    - Analog In: input pins take an analog signal and perform a 10-bit analog-to-digital (ADC) conversion to turn it into a number between 0 and 1023 (4.9mV steps).
    - Digital out: A digital out pin can be set to be HIGH (5v) or LOW (0v). This allows you to turn things on and off.
    - Analog out: PWM LED's & Motors

10 min. break
Homework:
Build one working Arduino circuit on a breadboard (either from a tutorial or original)
http://arduino.cc/en/Tutorial/HomePage
http://oomlout.com/a/products/ardx/
http://electronicsclub.info/study.htm

https://www.sparkfun.com/tutorials

Class #6:

- Review Homework Assignment: Test circuits (30 min)
- Arduino demo #1: Analog Read Serial 20 min.
  - Create your own analog read / potentiometer circuit
  - http://arduino.cc/en/Tutorial/AnalogReadSerial
- Arduino demo #2: PWM circuit with an 20 min.
  - To try out PWM yourself, connect an LED and 220 ohm resistor to digital pin 9, in series to ground. Run the following example code: File --> Examples --> 3.Analog --> Fading
  - http://arduino.cc/en/Tutorial/Fade

5 min. break

- Arduino demo #3: Digital Read Serial 20 min.
  - Create your own digital read / push button circuit
  - http://arduino.cc/en/Tutorial/DigitalReadSerial
- Arduino demo #4: Analog In Out Serial 20 min.
  - Create your own analog in out potentiometer circuit based on the two circuits above (PWM & Analog Read) that you've already created.
  - http://arduino.cc/en/Tutorial/AnalogInOutSerial

ADVANCED OPTION: Combine the PWM circuit with the Digital Read or Analog Read circuit to either turn the fading LED on or off with the push button or control it's speed via the potentiometer!

LUNCH

- Continue to review contemporary artists working in electronic arts: 1 hr.
  - Daniel Rozin
  - Wifaa Billal
  - Scott Snibbe
  - Daniel Palacios
  - James Clar
  - 3waylabs: Modular Cubatrons
  - FESTO!!!! (http://goo.gl/yTFGsg) http://www.festo.com/cms/en_corp/10924.htm
  - Other bionic / biologic robotic arm videos if time allows

- Meet with Teams to review final project progress and to make final parts orders. 1 hr.

10 min. break

- Presentation of new components via the Arduino: 1 hr.
  - Servos: http://arduino.cc/en/Tutorial/Knob
  - Solenoids & relays
  - Transistors & Audio Chips
- Break into final project teams and incorporate one or more of the newly presented components into an original Arduino sketch in class. Think of ways to integrate new sensors into final projects! 1hr.

Homework:

Create either the circuit from the servo tutorial listed above or create your own transistor circuit. First create a circuit diagram in Fritzing & transfer to Arduino protoboard as a functional circuit. This homework assignment can be a part of your final project!
Work on prototypes for final projects.

Class #7:

- Prototypes due for class demo / critique 1hr.

10 min. break

- Programming with the Arduino IDE (1 hr.)
    - This is not a programming class, so this will be a brief intro (many of you have a programming background already). In this class you will become a "patcher" of programming.
    - Arduino can be divided into three main parts: http://arduino.cc/en/Reference/HomePage
        - ♣ Structure
        - ♣ Values: Variables & Constants
        - ♣ Functions
    - code structure: Users only need define two functions to make a runnable cyclic executive program
        - ♣ setup(): a function that runs once at the start of a program that can initialize settings
        - ♣ loop(): a function called repeatedly until the board powers off
    - Control Structures
    - Syntax
    - Operators
    - Variables / Constants
    - Functions: Digital, Analog, Due only, Advanced I/O ()
    - Time
    - Interrupts
    - Serial & Stream communication
    - Math operations
    - Libraries
- Workshop on DC Motors:1hr.
    - Servo
    - Stepper
    - Gear Head

LUNCH

- Review & Discuss the following artists: 50 min.
    - Douglas Easterly & Matthew Kenyon
    - Cohen Van Balen
    - Helle Jorgensen
    - Michael Burton & Michiko Nitta
    - OCBC Supertree Grove
    - Eric Poulos
    - Bjoern Schuelke
    - Nano Robotics Lab (CMU)
    - France Cadet
    - Philip Beesley

10 min break

- Workshop for advanced sensors for Arduino, including: 1 hr.
    - Pressure sensors (http://learn.adafruit.com/force-sensitive-resistor-fsr/using-an-fsr)
    - Luminosity Sensor: http://learn.adafruit.com/tsl2561/overview
    - Temperature Sensor: http://learn.adafruit.com/tmp36-temperature-sensor
    - Accelerometer: http://learn.adafruit.com/adafruit-analog-accelerometer-breakouts
    - Vibration Sensor: http://learn.parallax.com/vibra-tab-arduino-demo
    - PIR Motion sensor: http://learn.adafruit.com/arduino-lesson-17-email-sending-movement-detector
- Students will break up into final project teams and develop and test their own Arduino Circuit with a chosen advanced sensor and motor. Think of ways to integrate it with your final project! 1hr.

Homework:
Work on final projects.

Class #8

- Advanced Sensors Part 2 1hr.
    - Flex sensor (same as pressure sensor)
    - Mic / amp sound sensor: http://learn.adafruit.com/adafruit-microphone-amplifier-breakout
    - Close proximity sensor: http://numato.com/vcnl4000-integrated-proximity-and-ambient-light-sensorjoystick
    - Water quality sensors
- Presentation of digital art projects from events / festivals such as: 1hr.
    - Theo Jansen – Strandbeest (http://www.strandbeest.com/)
    - Ars Electronica: http://www.resoundings.org/
    - Documenta: http://d13.documenta.de/#welcome
    - ISEA: http://www.isea2013.org/
    - Future Everything: http://futureeverything.org
    - HTMlles: http://www.htmlles.net/
    - onedotzero: http://onedotzero.com/projects
    - Browserday: http://www.nl-design.net/browserday/6/
    - 404 Festival: http://404festival.com/en/
    - Nuit Blance: http://www.montrealenlumiere.com
    - Luminale: http://light-building.messefrankfurt.com/
    - Zero One: http://zero1.org/
    - Burning Man: http://www.burningman.com/art_of_burningman/bm13_theme.html
    - Rehappening: http://www.rehappening.com
- 10 min. break
- Class discussion of design for installation / presentation (site specific vs. stand alone) and “bombproofing.” 50 min.

LUNCH

- Demo on PCB circuit board soldering / development 20 min.
- Students will design & solder their own simple PCB board circuits. 1hr. (this can be a component within your final project!)

10 min. break

- Final Project Lab / Class / Debug / Project Development time 1 hr. 30 min.
    - Review schematics and progress with each team.

Homework:
Work on final projects.

Class #9:

- Individual Progress review / Check-In time with each project team and the instructor. 1.5 hrs.
- Final Project Lab / Class / Debug / Project Development time 1.5 hrs.

LUNCH

- Final Project Lab / Class / Debug / Project Development time 3 hrs

Homework:
Work on final projects.

Class #10:

- Final Project Lab / Class / Debug / Project Development time 3 hrs.

LUNCH

- Final Project Lab / Class / Debug / Project Development time 1hr.
- Final Projects DUE by 4pm for class presentations & demos / class critique

Homework:
Write a 1000 word project description / reflection on your final project. Write about your research, the process and your own reflections on the project. (Due by 10pm on Sunday, Sept. 1st, uploaded to E-commons drop box)

Objectives:
To produce conceptually interesting and formally compelling artwork.
To understand the principles of interactive electronics in the arts.
To be able to relate traditional sculpture principles of form, material and site and utilize interactive electronics to virtually give rise to an installation or sculpture.
To develop an aesthetic that includes the use of micro-controllers in the creation of time based, interactive artworks and environments.
To offer intelligent and informed critiques.
To develop original ideas and concepts.
To develop an awareness of artists working in the field.

Requirements:
Attendance is a must and worth 10% of your grade. Due to the accelerated nature of the class, missing one day is the equivalence of missing an entire week. Only medical or family emergencies will be accepted. Please contact the instructor before class, in either of these cases. No exceptions.

In class participation during general discussions and especially during critiques, is required and is worth 10% of your grade! Out of class reading and writing assignments will also required and graded throughout the quarter as well as additional homework assignments given out in class.

Weekly Assignments are worth 40% of your grade. (10 points per week). There will be weekly assignments ranging from tutorials to reading assignments to specific electronic

based assignments. Finishing and turning on time all of the weekly assignments is integral to a practical understanding of the material. All weekly assignments are due by midnight on Sunday before the following weeks class and should be uploaded to the drop box on e-commons when applicable and ready to share in class on the following Tuesday.

Final Group Project (project 20%, paper 10% & Presentation 10% of final grade)
The course will culminate with final group projects and presentations based on the overall conceptual theme of "Ocean Ecology & Sustainability". Teams will be determined according to student interests and skill sets in the hopes of creating balanced teams of expertise. The criterion for the final project is an electronic based artwork that collects data and produces a controlled output. The final project will also be supported by a 1,000 word paper discussing the conceptual and technical information and contributions of each team member and the creative motivations behind the work, as well as a 10-minute demo and presentation in class.
The final group project must include: (see class schedule for due dates)

- A one page written proposal with sketches
- A timeline & budget
- A list of materials needed (in relation to budget & timeline)
- The use of a microcontroller, input (sensors, etc.) & output devices (LED's, motors, etc.)
- A fully soldered circuit (bread boards must be transferred to soldered PCB boards) that is contained within an enclosure. (enclosures can be ordered or built on the laser cutter).
- Each team member must write their own 1,000 word paper about the project. (Due by 10pm on Sunday, Sept. 1st, uploaded to E-commons drop box)
- A group class demo / presentation of the project. (20 min. each)

Required & Suggested Reading:
- Braitenberg, Valentino. (1998) Vehicles . (6th edition).
- Scherz, Paul. (2007) Practical Electronics for Inventors . (2nd Edition).
- Mims III, Forest M. (1983). Getting Started in Electronics . (12th edition).
- Banzi, Massimo. (2011). Getting Started with Arduino. O' Reilly Media.
- Select PDFs from Peter Elsea's archive

*All sources are available either online, in class or on reserve at McHenry Library

Evaluation:
Evaluation will be based on the following:
1. The quality of class participation, including contribution to critiques, discussions and in class presentations.

2. The quality of your completed assignments with your comprehension of concepts, demonstration of your effort in achieving your goals, the exploration of new ideas, and your personal development.

3. Students must demonstrate satisfactory achievement of course objectives through fulfillment of course projects and by contributing to class discussions and critiques.

4. All projects will require students to work both inside and outside of class. Assignments turned in late will be decreased by 1/2 points for each day the assignment is late. Example: 20 points will equal 10 after 1 day. 20 points will be 5 points after 2 days late.

5. Completion of each weeks project assignment.

6. Final evaluation will be in the form of a final project to be determined in the 3rd week of the class.

Grading:
Attendance = 10 points (2 points per week)
Class participation = 10 points
Week 1 Assignments = 10 points
Week 2 Assignments = 10 points
Week 3 Assignments = 10 points
Week 4 Assignments = 10 points
Final Project = 40 points

Total possible points = 100 points

Grading scale:
A = 94 - 100 A- = 90 - 93
B+ = 88 - 89 B = 83 - 87 B- = 80 - 82
C+ = 78 - 79 C = 73 - 77 C- = 71 - 72
D+ = 69 - 70 D = 64 - 68 E = 0 - 63