The Fab Academy Handbook

A resource for Students, Local Instructors, New (and Old) Labs and Gurus alike

Rev.1.0 - 2015 Edition

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Introduction

The role of Fab Academy is to initiate, mentor and technically train new students for participation and leadership in the global Fab Lab Network community. It's how we train our teachers.

It's also a great way to gain exposure to a wide variety of digital fabrication, electronics, molding and casting and composites practices and build skills in a short amount of time (typically 19 weeks). It's not for the faint of heart (see the course requirements and 2015 schedule), but the rewards are great.

This document is written for those interested and/or participating the Fab Academy (both current and aspiring students and labs). It assumes that you already know what a Fab Lab is - and that you already have one or are in the process of setting one up.

What's a Fab Lab?

If you have stumbled across this document via search and do not know what a Fab Lab is - or you want to set up your own Fab Lab - please see these Fab Foundation resources:

- What are Fab Labs?
- Setting up a Fab Lab
- Official Fab Lab FAQ
- Detailed info about labs around the world

New and Aspiring Labs: Basic Requirements

Basic Requirements for Fab Academy Participation

Here are the basic requirements and expectations for any lab that wishes to participate in the the Fab Academy course.

Your lab MUST be equipped with the ALL necessary digital fabrication machines, electronics

components and other supplies to be able to participate in the Academy. Labs that are not properly equipped are not eligible to participate in the Academy, as the students will not be able to complete the course.

To determine if your lab is eligible for Academy participation, please submit your lab information to the following form: Fab Lab Application Form

As this is a bleeding edge program, hardware and electronics specification is continually being updated. For the most up-to-date list of recommended machines and supplies, see: the Fab Lab Inventory

Necessary Machine Types

- A computer-controlled lasercutter, for press-fit assembly of 3D structures from 2D parts
- A large (4'x8') numerically-controlled milling machine, for making furniture- (and house-) sized parts
- A signcutter, to produce printing masks, flexible circuits, and antennas
- A precision (micron resolution) milling machine to make three-dimensional molds and surface-mount circuit boards
- Specific machine models are listed in the Fab Lab Inventory

Necessary Supplies

- Programming tools for low-cost high-speed embedded processors
- Course-required surface mount electronics components
- FR1 stock for machining circuit boards
- Molding and casting supplies
- Composites supplies
- Cardboard, sheet plywood and other consumable stock materials

Do I need these specific machines and electronic components?

Yes - you do.

In order to fully participate in the class you will need the electronics components and other supplies. Do not skimp on the electronics, about half the course utilizes these components.

In some rare cases, non-Fab Lab Inventory machines may be substituted, but this often causes serious problems for the students as the Academy Gurus are unable to support the unfamiliar machines remotely when things go wrong.

We recommend the machines in the inventory for a reason, we have found them to be reliable, affordable and able to perform the necessary course tasks. Other machine will be considered on a

case-by-case basis if your lab applies to be a Fab Academy site.

It also violates the core Fab principle that “Fab labs share core capabilities, so that people and projects can be shared across them.” - Neil Gershenfeld, Fab Lab FAQ

Local Class Working Groups

What is the maximum / minimum number of students in a local Fab Academy class?

Beyond a Local Instructor, a workgroup of students is required in order to create the necessary collaboration environment for a successful Fab Academy class.

We have found that it is (nearly) impossible for a student to complete the course on their own and workgroup ensures that one student’s strong suit may help make up for another’s weak spots and vice versa.

Here are the general guidelines for Class Working Groups:

- CRITICAL MASS NECESSARY: They are made up of a Local Instructor and at least 3 students or 3+ students and a Remote Guru.

- PREVENTING INSTRUCTOR OVERLOAD: Groups larger than approximately 10 students per Local Instructor or Guru are not recommended, simply because there are not enough hours in the weekly cycle for each of those students to receive appropriate guidance from a single individual.

- MACHINE LOGISTICS: In the case of multiple Local Instructors / Gurus in one lab, another 5 students can be enrolled for a recommended maximum of 15 students, as the problem now becomes a logistical one of students vs machines and machine time available (assuming standard inventory quantities).

- REMOTE LOCATION CONSOLIDATION: Likewise, it is not recommended that Guru support more than 5? remote students and every attempt should be made to group remote students in such a way that Gurus do not have students in more than one remote location.

Basic Fab Academy Course Info

2015 Weekly Schedule and Topics Covered

Subject to change: see http://fabacademy.org/archive/courses/index.html

- principles and practices, project management (Jan 28)
- computer-aided design (Feb 4)
- computer-controlled cutting (Feb 11)
- electronics production (Feb 18)
- 3D scanning and printing (Feb 25)
- electronics design (Mar 4)
- embedded programming (Mar 11)
- computer-controlled machining (Mar 18)
- molding and casting (Mar 25)
- break (Apr 1)
- input devices (Apr 8)
- output devices (Apr 15)
- composites (Apr 22)
- networking and communications (Apr 29)
- interface and application programming (May 6)
- applications and implications (May 13)
- mechanical design, machine design (May 20)
- invention, intellectual property, and income (May 27)
- project development (Jun 3)
- project presentation (Jun 10)

Class Meeting Times

Global lectures happen on Wednesdays at 9:00 on the US East Coast (ranging from 6:00 on the West Coast to 23:00 in Japan). Global lab sections will be held on Fridays, and regional reviews on Tuesday.

Classes take place weekly on Wednesdays, January through June at 09:00 EST (15:00 CET/14:00 GMT/ …) and last for approximately 3 hours. See the current schedule for detailed information.

Local Instructors and Gurus are also required to attend the weekly prep meeting which takes place weekly, 30 minutes before the start of class.

Weekly Homework Reviews / Help Sessions (Experiential 2015)

Homework review sessions led by Gurus will be staggered according to global time zones and take place the day previous to class, on Tuesdays. Exact time will be confirmed by the SN Guru before the start of course.

All sessions take place on the MCU conferencing system on channel 3 - Class. More information on this in the section below entitled “Video Conferencing”.

Due to the limited number of MCU connections, students must go to their lab to participate with their local working group.

Students: Basic Course Requirements

Student Time Commitment

The time commitment is about 16+ hours a week at minimum, but could be far greater if the student is highly motivated, does not possess the background for a particular unit (or units) or just wants to really throw themselves into the program.

Required Documentation

Students are required to document their work each week for the unit covered and homework will be reviewed during each weekly class cycle. Your local instructor or remote guru will review your documentation in detail every four weeks to make sure you are making sufficient progress.

Your Fab Academy documentation must show completion of the unit and core skill competencies. It will be in HTML format and must be able to exist within a Mercurial archive (no PHP).

At minimum, the Global Evaluation Committee expects a student's documentation to include:

- A text description of their project for the week
    - designing and fabricating the work
- Supporting photographs (video is great, but not required).
- All final fabrication files in their original, editable formats
- All code in an editable format, testable format
- What the student learned: what succeeded and what failed.

It is recommended that students choose a licence for their work prior to the start of publicly posting their files.

Sharing Digital Files and Code

You must share all of your digital design files and code (where applicable) to pass the unit.

Student Rights and Expectations

You have the right to expect:

- access to working and well-maintained digital fabrication machines in your local lab.
- that all the necessary course materials will be provided for you by the local lab before the

necessary unit.
    - this includes sheet goods, molding and casting supplies and electronics components
- meeting at least three times a week with your local instructor.
    - two meetings are devoted to hands-on machine instruction, general lab access and direct physical access to the local instructor for questions, tutoring, etc.
    - the third session each week is devoted to Wednesday's lecture session with Neil Gershenfeld.
- that your local instructor / remote guru will be available to answer questions via email during the week - outside of class.
- that your local instructor will give you meaningful feedback on your work and documentation. If your documentation is unsatisfactory, the Local Instructor will help you to get it up to par.

If you have a Remote Guru assigned, you should expect that:

- the Guru will contact you to set up a mutually agreed upon weekly video check-in session to help you with any questions you may have.

Student Responsibilities

It is your responsibility to be proactive in the Fab Academy course. This course offers a great deal of personal freedom.

However you are responsible for:

- designing and fabricating your own projects
    - it's fine to begin with someone else's files, but it is not acceptable to pass someone else's work off as your own.
    - Cite all your sources and inspirations.
- getting your work done on time for each weekly cycle.
- documenting your work in HTML
- ensuring that your documentation is in the class archive. Work that is not in the archive will not be evaluated.

Academy Roles and Key Personnel

Fab Academy Staff and Contacts

Below are the contacts and roles of some of people which you may need to get in touch with throughout the course.

Prof. Neil Gershenfeld
Fab Academy Program Director
instruct@fabacademy.org

Sherry Lassiter
Director Fab Lab Program and Fab Foundation
sherry@fabfoundation.org

Anna Kaziunas France
Fab Academy Dean
anna@fabacademy.org

Tomas Diez
Fab Academy Global Coordinator
coordination@fabacademy.org

Luciana Asinari
Fab Academy Admission Office
luciana.asinari@iaac.net

Supply Chain:

US, South America or Asia: please contact Jean-Luc Pierite directly at:
jeanlucpierite@fabfoundation.org

Europe, the Middle East or Africa: Fab Lab Barcelona also manages stock for the Fab Foundation. To order from them please email: **orders@fablabbcn.org**

What Are "Gurus"?

Fab Academy Gurus are individuals who have shown mastery of the broad range of HTMAA and have earned the respect of their peers through their years of service to the Academy.

The role of Fab Academy Guru is to initiate, mentor and technically train new Fab Academy students for participation and leadership in the global Fab Lab Network community.

As many students are without strong local mentorship, the Guru's a key task is to monitor the students or labs placed in their charge - clearly communicating both class expectations, answering their questions, supporting them (through both email and weekly video conferencing) and monitoring and tracking their progress and attendance.

Gurus may be Local Instructors or they may be physically located elsewhere and function as a Remote Guru for another lab.

Guru Responsibilities

It is the Guru's responsibility to work with their assigned students and the local lab they mentor to verify that both equipment and supplies are available to the students in time for weekly assignments.

While a Guru's primary role is to keep a lab accountable and students "on task", Gurus are also cheerleaders, and at all times should provide moral support and motivation to struggling or overwhelmed students.

On Guru-ing

Being a Fab Guru is more of an art than a science. Like each student, Gurus have very different backgrounds and each has their own style, interests and "experiential wisdom" to transmit to students.

There is no "single right way" to Guru - student's skills, software choices and project aspirations will all be very different. A Guru's duty is to mentor students on the Fab Academy Path, imparting wisdom that will help them successfully complete the course.

"I Don't Know, but I'll Find Out" is an Acceptable Answer

Gurus teach "How to Make Almost Anything". It's a team effort, no one knows every facet of every area. Gurus often work as a team, using other instructors as resources.

Current Active Fab Academy Gurus

- Anna Kaziunas France
    - Specialties, what I like to make, role, ask me about…...TBD
- Bas Withagen
    - Specialties, what I like to make, role, ask me about…...
- Shawn Wallace
- Mercedes Mane
- Luciano Betoldi
- Alex Schwab
- Tomas Diez
- Nuria Robles
- Etc (Gurus - you know who you are, add yourself here)

Distinctions Between Gurus and Local Instructors

As the network grows we have found it necessary to further distinguish between those with experience teaching Fab Academy and those who are just starting out.

What Denotes a Guru?

A Guru is a senior instructor. Gurus have 3 or more years of Academy teaching experience, making them qualified to take on students without direct supervision.

Who Can Be a Fab Academy Local Instructor?

The first requirement for becoming a Fab Academy Local Instructor is to complete the Fab Academy program satisfactorily.

Year 1: Local Instructor with Mandatory Support and Supervision

- Fab Academy graduates (with the recommendation of their instructor or remote Guru) are eligible to be local Fab Academy Local Instructors.
- They must have the help of a remote Guru and / or supernode support during their first year.

Year 2+: Stand Alone Local Instructor

- Second and third year instructors are eligible to be local Local Instructors (with the recommendation of their supernode / remote Guru) without direct remote supervision.

Video Conferencing

Necessary Hardware / Connectivity

- internet access (recommended at least 1MB upload/download speed)
- a webcam (or one built into your computer)
- a noise canceling microphone (or headphones with a built in mic for individuals)

A noise cancelling speakerphone is recommended when connecting through a computer as a group for class (as opposed to a Polycom system). We currently recommend this speakerphone, but see the Fab Lab Inventory for the latest recommendation.

Class Location (MCU / MCUC)

All classes and most meetings will take place on the CBA MCU.

- The address of the MCU is 18.85.8.48
- The address of the MCUC is 18.85.8.50
- Fab Academy Lectures are held in room 4 “Class” (4@18.85.8.48, 4@18.85.8.50).
- The PINs are distributed via email.

Recommended Software

Currently Cisco Jabber Video is the easiest to configure, is available for multiple OS (and mobile devices) and provides good audio and video quality.

The CBA maintains a detailed list of compatible video conferencing clients and MCU technical connection details.

How to Connect Using Jabber

- Enter v in the field where it says to "Type name, number of address"
- Here's a very short step by step video of how to connect via Jabber (and what to do and expect to see on screen while connecting via any client).

NOTE: You may want to connect to 1@18.85.8.48 to test your audio and video. "1" is the general Fab Lab channel and there are usually several labs connected that can help you test your audio and video.

Here's what a MCU is and how it works:

"Simultaneous videoconferencing among three or more remote points is possible by means of a Multipoint Control Unit (MCU). This is a bridge that interconnects calls from several sources (in a similar way to the audio conference call)." - Wikipedia Entry (for more info)

This means that you can talk directly to all the other participants, including Neil Gershenfeld, and ask questions during our Wednesday lecture sessions.

Video Conferencing Etiquette - IMPORTANT!

Because everyone connected to the MCU can hear each other, it is vital that you mute your microphone when joining a conference and UN-MUTE ONLY WHEN SPEAKING. See video for how to do this.

Failure to mute will cause a disruptive feedback echo that will SERIOUSLY interfere with the audio quality, making class unpleasant.. Neil can see who is the source of the problem and will mute you, so failure to mute is potentially embarrassing. Practice connecting prior to class.

Similarly, make sure that your camera is on and that all class participants are visible (if possible). Light the participants from the camera side and eliminate back lighting as much as possible, so everyone connected can see you.

Email Lists

As previously noted with regards to video conferencing, etiquette should also be observed in email conversations. Several email lists exist in order to make communication between the different groups within the Fab Academy structure easier and more organised.

class[year]@fabacademy.org
This is an email alias shared by all current Fab Academy students. class14@fabacademy.org is for the 2014 class, class15@fabacademy.org for 2015, etc.

instruct@fabacademy.org
This is an email alias shared by all current Fab Academy Instructors.

globaleval@fabacademy.org
This is the email alias for the Global Evaluation Committee tasked with grading.
alumni@fabacademy.org
This is an email alias onto which all graduates are entered upon completing Fab Academy.

Email List Etiquette
The following email lists are high-volume lists. Students should first discuss their issue with their Local Instructor or Remote Guru if possible.

Custom Email Lists
As an instructor or supernode Guru you may also choose to create your own alias in order to facilitate internal communication between your student's (remote and local) and even yourself or your staff. i.e.: academy@FabLabbcn.org

Accepted Academy Sites: Getting Started

Basic Lab Expectations

- The "Basic Requirements" have already been met
- There is a Local Instructor present or a Remote Guru has been assigned
- If the Local Instructor is new (first year as an instructor), they are officially assigned to and being mentored by a Remote Guru.
- Local instructors will attend prep meetings each week at 08:30 EST
- Local Working Groups (comprised of students and instructors) will attend lecture together from the local lab every Wednesday at 09:00 EST

Class Participation: Internet Access

The Fab Academy meets as a class for lecture, homework review and other meetings via videoconference. You must have a reliable internet connection to participate.

- For connectivity requirements see the Video Conferencing section.
- For class meeting times see Basic Course Info section.

New Lab Checklist: Complete These Tasks Prior to 1st Class

- Your lab has all the digital fabrication machines set up and ready for immediate student use.
- You have ordered (or are working with the Fab Foundation to order) all the necessary course materials.
- Your lab meets the Video Conferencing requirements AND your lab has "test connected" to the MCU PRIOR TO CLASS to ensure that:
    - your network can handle the bandwidth required
    - you have the necessary hardware
    - understand how to mute your microphone
    - we have a pleasant and trouble-free first class ;-)
- "**How to Connect" to the MCU Quickstart**
- Your lab's Local Instructor is on the instructor list (instruct@fabacademy.org). If you have not been receiving emails, you are not on the list. Contact Fab Academy Coordination
- You have clearly communicated your student's email addresses to Fab Academy Coordination so your students have been added to the "Class" email list.

New Remote Guru Checklist: Prior to 1st Class

Complete the tasks on the the "New Lab Checklist" above - PLUS You have arranged a mutually agreed upon WEEKLY MEETING TIME with your remote students to go over homework. problems, etc.

Local Instructor and Remote Guru Responsibilities and Requirements

Instructor Prep Meetings

In addition, we will meet as instructors each week, it is vital that you attend every prep meeting.

Weekly Time Commitment: Local Instructors

Local Instructors should commit to a **minimum of 16 weekly hours** on their duties during the Fab

Academy program (January to June) divided into the following categories and based on a class of ~5 students:

- Prep meeting and Neil's Lecture **(3.5h)**
- Homework Review **(1.5h)**
- Student support hours **(6h-8h minimum)**
- Grading **(1h)**
- Stock control and ordering **(2h)**

Weekly Time Commitment: Remote Gurus

Remote Gurus working with labs without a local instructor should expect to spend **a minimum of 6 weekly hours** on their duties.

1-2 weekly hours per remote student, attend lecture and prep meetings and may need to take on additional tasks - depending on their agreement with the local lab and the level of help needed.

- Prep meeting and Neil's Lecture **(3.5h)**
- Homework Review **(1.5h)**
- Remote student support hours **(1h-2h per student)**

Remote Gurus are REQUIRED to meet with their mentee lab / students for a video check-in session each week. This is vital to the success of remote students.

Possible Guru Tasks (no local instructor)

- Grading **(1h)**
- Stock control and ordering **(2h)**

Time Commitment: Final Student Evaluations

During the final grading at the end of the class - which determines if a student has graduated - Local Instructors and Remote Gurus should expect to spend approximately 6-8 hours reviewing their student's work BEFORE submitting those they believe to have completed all assignments and final project successfully to the Global Evaluation Committee.

Senior Instructors (2+ years experience and have completed at least one grading cycle on their own are required to serve on the Global Evaluation Committee to help out with the final student review process. The number of enrolled students continues to grow and many hands make light work (and decrease the individual time commitment).

Application Process: Screening Students.

Local instructors need to interview and inform their prospective students. It is the Local Instructor's

responsibility to ensure that incoming students understand the course's time (**16+ hours a week minimum**), participation and documentation requirements, as well as the grading benchmarks used for evaluation.

Supply Chain: Stocking and Ordering

The continually updated Fab Lab Inventory specifies the current list of required materials and machines. While some of the vendors listed are worldwide distributors, others are US only. This is noted in the inventory. Alternative vendors are listed (temporarily) in the "Content" repository.

Announcements regarding changes in inventory or new items are sometimes made during the weekly prep meetings. **Local Instructors are responsible for ordering supplies for their students** and should leave some extra funds in the budget to account for new items being introduced during the course.

Local ordering for the Fab Academy program (especially for Specialty Items) should ideally be made in it's entirety ahead of the start of the course. However, this is not always possible. It is then of the utmost importance to keep track of upcoming assignments and have items in stock and on premises at least 4 weeks in advance to when they will be needed, minimising the impact of possible shipping delays.

Some of the items we use are sometimes difficult to obtain in certain countries and this advanced purchasing timeframe is essential to ensure students are able to complete assignments on time.

Ordering Specialty Items: FR1 & Micro-Endmills, MTM(m) Stages

Some specialty items are difficult to find in small quantities, **specifically, FR1 stock and micro-resolution endmills** used for all of the electronics units.

The Fab Foundation buys these items in bulk and can provide small quantities and at cost value to all participating labs.

- **US, South America or Asia:** please contact Jean-Luc Pierite directly at: **jeanlucpierite@fabfoundation.org**

- **Europe, the Middle East or Africa**: Fab Lab Barcelona also manages stock for the Fab Foundation. To order from them please email: **orders@fablabbcn.org**

Mercurial Repositories

Local Instructors are responsible not only for teaching their students how to use the Mercurial repository correctly, but also for fixing any trouble their students may cause to it.

While this is part of the learning process for both Local Instructors and students, you may choose, at least at first, to use an intermediate repository that students push to and which the Instructor manually syncs weekly to the main repository.

You may do this by either setting up your own installation of Mercurial Server locally, or request that one be setup for you at the start of class in the main Fab Academy server.

NEED NEW “HOW TO CLONE” TUTORIAL FOR NEW INSTRUCTORS, IT’S A LITTLE CONFUSING THIS YEAR.

Managing Final Projects

Local Instructors also help students manage their time and provide guidance towards the creation of feasible final projects that can be accomplished by each student (students have different skill sets) within the duration of the course.

Local instructors and Remote Gurus must work with the students to ensure they have everything in stock, or that they order well enough in advance. You must also leave a little room in the budget for final project supplies.

Grading and Final Evaluation Schedule

Evaluation Schedule

Local Instructors should be evaluating student work periodically throughout the course. A bi-weekly review is good, a weekly review with the student is ideal.

Instructors must review each student’s work according to the documentation provided by the student, NOT what was observed in the lab. Instructors should discuss incomplete work / documentation with a student on an ongoing basis. There should be no surprises at the end of the course.

In order to complete the program students need to satisfactorily complete *all* assignments and their final project.

2015 Review Schedule

See: Neil’s timeline document

Global Evaluation Committee

Members of the global evaluation committee will each spend additional 10-20 hours making the final decision on graduation.

Volunteer - Help Us Out!

Have you been an instructor in the Academy for two or more years? Will you have completed one grading cycle as an instructor by July 2015?

If so - we need you! Academy enrollment grows exponentially every year. Many hands make light work.

If you'd like to volunteer, email globaleval@fabacademy.org with the **subject heading "Eval Committee Volunteer"** and note labs and years as an instructor.

How to Contact the Committee for Re-Evaluation

I realize that there are a few of you (or your students) that were missed or slipped through the cracks during the last round.

Any instructor who has a student that needs to be re-evaluated from a previous year should:

1. Review the student's work themselves first
2. If the student is complete, contact globaleval@fabacademy.org
3. Use the *email subject heading* **"Re-Evaluation Requested: STUDENT NAME"**
4. Then the committee will review and determine final graduation status

Use of consistent subject headings will help us sort and filter our huge piles of email much more easily and **enable us to more quickly address your situation.** We truly want to get last year's limbo graduation decisions resolved.

Why Re-Evaluation Backlogs Happen

The Evaluation Committee members are **volunteering large amounts of their time** to review student work - after teaching the Academy all semester. Please keep this in mind.

We can set a make-up date for those who didn't make the cut after Fab11. However, the major reason we are behind on evaluations is because the Committee is tapped out from all the last minute additions and trying to get people attending the conference through graduation. We all have other jobs and responsibilities and if we don't stick to the schedule, folks slip through the cracks.

Fab Academy Evaluation Criteria

Necessary Skills and Requirements for the Fab Diploma

The Fab Diploma is awarded to those who demonstrate mastery of the basic skills required to use all Fab Lab machines through their written documentation.

SHORT EVALUATION CHECKLIST:

There is a **much shorter checklist** to be filled out prior to graduation

IN DEPTH EXPLANATION

The following explains why we require this criteria for the Fab Diploma and what students should have been taught by their local instructors during the course.

BASIC COURSE REQUIREMENTS:

All work must be in the class archive

1. All fabrication files and code must be present in original formats
2. Code must run (screenshots alone are not acceptable)
3. All weekly units must be completed
4. Final project must meet basic requirements

Overall Core Outcomes/Skills:

- Basic competency on all fab lab machines
- Basic understanding (at minimum) of each weekly unit
- Personal Time Management
    - weekly cycle: learn -> design -> fabricate -> prototype -> repeat?
- Personal Project Management
    - supply side vs demand side
- Collaborative Technical Development
- Triage and Troubleshooting
- Patience, perseverance and tenacity

PRINCIPLES AND PRACTICES, PROJECT MANAGEMENT

Skills Acquired:

Version Control Basics

- Has demonstrated basic understanding of Mercurial
- Understands the concept of distributed version control.

Required for Completion:

- HTML page(s) that documents a student's work.
- Student has made commits in the Academy archive.

What's the Point?

- Projects need to be documented.
- A basic understanding of HTML and version control are the norm for technical individuals.

COMPUTER-AIDED DESIGN

Skills Acquired:

- Student understands the concept of both 2D and 3D digital design
- Is able to convert an idea both a 2D or 3D design

Documentation Required for Completion

- Original 2D design files
- Original 3D design files
- A description of the software experimentation process.

What's the Point?

- The ability to design 2D and 3D CAD files is an essential part of digital fabrication.

COMPUTER-CONTROLLED CUTTING

Skills Acquired:

- How to 2D design and fabricate press fit construction for the laser cutter.
- How to use the vinyl cutter for stickers, signs, masks and antennas.

Documentation Required for Completion:

- Description of process
- Images of the student using both the laser and vinyl cutter
- How to make your press fit construction kit
- The original design files.

What's the Point?

- Learn to use both the vinyl and laser cutter.

ELECTRONICS PRODUCTION (WEEK 1 OF 2)

Skills Acquired:

- learn how to use a high precision milling machine to fabricate boards
- learn how to use a high precision milling machine - period, for 2D fabrication.
- learn surface mount soldering skills
- set up programming toolchain + GCC

Documentation Required for Completion:

- Make a FabISP
- Description of the process
- Photos of the process
- Design files (only if you created a new design).

What's the Point?

- Learn how to use the Modela milling machine to fabricate circuit boards.
- Intro to surface mount soldering and a little about the components.
- Cost, speed - iterations, adaptability (for physical issues)
- Understanding of basic electronics prototyping and digital design.
- Breadboards can have internal issues, hard to see connections, can break internally.

Outliers: If board is not working, multiple efforts and troubleshooting steps taken, shown and documented.

COMPUTER-CONTROLLED MACHINING

Skills Acquired:

- Learn to design for and operate a large format CNC router
- Acquire a basic understanding of:
    - Feeds and speeds
    - Tooling
    - Toolpath generation
    - Materials (plywood at minimum)

Documentation Required for Completion

- Original design files of student's own design

- Must machine “something big”, files must be cut.
    - Molds too large for the Modela are all acceptable.
- Design files
- Tooling, feeds & speeds and materials used.

ELECTRONICS DESIGN (WEEK 2 OF 2)

Skills Acquired:

- Learn to modify (at minimum) a circuit board using “electronics design software”.
    - Typically Eagle, but not required - any software acceptable.
- Ability to identify components and their functions
- Able to:
    - Modify a schematic
    - Lay out a board
    - Understand pad vs part footprints
    - Route traces
    - Understand part units, package sizes
    - Check design rules to troubleshoot pre-fabrication issues
    - Import and use part libraries
    - (Optional) How to edit parts

Documentation Required for Completion

- Redraw the echo hello-world board or design your own.
- Add (at minimum) a button and LED with current-limiting resistor.
- Description and pictures of process
- The original design files (Eagle, KiCad, Inkscape - whatever)

What’s the Point?

- Learn very basic hands-on electronics design (at minimum)
- Practice electronics fabrication: board creation, fabrication file export and surface mount soldering.

EMBEDDED PROGRAMING

Skills Acquired:

- Intro to AVR microcontrollers.
- Able to understand datasheet basics
- Understanding In-System Programming
- Identify chip pinouts and their uses

- Discern between using a bootloader (Arduino) vs ISP.
- Difference between:
    - Programming -> one way, flashing data onto a chip
    - Serial Port (power and communication)
- Know the difference between AVR and Arduino platform (plus no ISP).

Documentation Required for Completion

- Document what you learned from reading a microcontroller datasheet.
    - What questions do you have? (optional)
    - What would you like to learn more about (optional)
- Description of programming process
- Program board in as many programming languages as possible (at least one)
- Your code must be documented (code must be executable, no screenshots!)
- At bare minimum, the example code must be modified

What's the Point?

- *Basic understanding of microcontrollers, ISP*
- How to talk to them in different languages
- Able to understand underlying logic of a chip, so that you can go beyond the limitations of Arduino-like platforms.

MICROCONTROLLER PLATFORM + SINGLE BOARD COMPUTER POLICIES

!!!!!!!!!!!!!!!!!!! IMPORTANT !!!!!!!!!!!!!!!!!!!!!

ACCEPTABLE USES OF ARDUINOS

!!!!!!!!!!!!!!!!!!! IMPORTANT !!!!!!!!!!!!!!!!!!!!!

- Prefabricated Arduinos can be used -- **BUT ONLY with networked, student custom-designed shields or connector boards.**
- **If you don't understand what that means, you can't use a pre-fab Arduino.**
- Fabricate your own "Arduino style" board with an ATMega chip, there are numerous fabbable designs available.

A core Fab Academy skill is understanding how microcontrollers work (READ THE DATASHEET!). Arduino and other platforms hide how these chips work. You need to understand the basics to acquire the very basic "embedded programming" skills required to pass.

ATMEL AVR MICROCONTROLLERS (and others…)

A microcontroller is a small computer on a single integrated circuit containing a processor core,

memory, and programmable input/output peripherals.

ARDUINOS and ARDUINO CLONES

Arduino is a microcontroller platform. It consists of:

1. Printed circuit board containing a microcontroller,
2. Input and output pins, power connections and parts (capacitors, resistors, ets) to be able to program the microcontroller
3. Pre-programmed microcontroller bootloader, can't reset the fuses, takes up memory.
4. An IDE
    1. Integrated Development Environment
    2. Arduino IDE supports C and C++
    3. Libraries
    4. Examples

SINGLE BOARD COMPUTERS: RASPBERRY PI, BEAGLEBONE

They are super cheap computers capable of running full operating systems, like Linux and (recently) Windows. PIs, Beaglebones, etc, **can be used as a computer interface (a substitute for your desktop/laptop).**

Students must still fabricate their own boards for each weekly assignment.

3D MOLDING AND CASTING

Skills Acquired:

- Designing 3D fabricatable CAD model for moldmaking
- Machining 3D files
- Learning about material safety
    - Read the Material Safety Data Sheet (MSDS)
    - Dangerous dust for lungs (MDF/Foam)
    - Respirators may be required
    - Protective clothing, ventilation, etc
    - Chemical properties, especially temperature!
- Basic knowledge of mold releases
- Understanding different types of casting materials and their properties
- Demolding procedures
- Food-safe vs. non-food safe

Documentation Required for Completion

- 3D mold designed, CAD files provided
- Mold machined
- Parts cast
- Machinable wax is recommended, not required
    - Foam is also acceptable
- Document process, tooling, materials, machine and feeds & speeds used (if feeds & speeds applicable)

3D SCANNING AND PRINTING

Skills Acquired:

- Design for 3D printing
- The strengths and limitations of 3DP
- How to use a desktop 3D printer
- Ability to generate a 3D model from an object using scanning
- Understand scanning output and file formats (mesh, point clouds, STL, OBJ)
- Mesh repair and manipulation (optional)
- Printing scans (optional)

Documentation Required for Completion:

- 3D scan an object
- Design and print a 3D print a model
    - File sharing site downloads are not acceptable
- Provide your design files
- Document the process
    - tools and materials used
    - troubleshooting tips
- Repair and print the scan (encouraged, but not required)

INPUT DEVICES

Skills Acquired:

- Learn about as many types of sensors as possible
    - understand the difference between analog/digital
    - measure environment
- Understand the pinout
- Understand how to get data out

- Be able to interpret the data
    - what is being measured?
    - how is it being measured?
    - how do you know if you are getting the right values?
    - what are the limitations, parameters?

Documentation Required for Completion:

At Minimum (electronics beginners):

- Fabricate the “hello world” input example boards
- Program them in as many languages as possible
- Understand why the “hello world” board needs the included components
- Grasp the “typical application”
- Make as many sensor boards as possible and thoroughly understand how they work.
- Document each sensor, what it does, what you learned.

Students with Previous Electronics Experience

- Above requirements, plus
- Design your own sensor boards
- Provide the design files
- Use new and unfamiliar sensors

What’s the Point?

- If the beginner student doesn’t understand how a sensor works and how read and interpret the data, plus the additional components needed for the “typical application” to get the proper data out then ...
- That student will never progress to designing their own boards for their final project.
- **The temptation to use an Arduino will be strong.**
- **Arduino use signals a “FAIL” on the part of the Academy and its Gurus.**
- We need to facilitate learning and the weekly cycle is short.

OUTPUT DEVICES

Skills Acquired:

- Learn about as many types of outputs as possible
    - analog/digital
- Grasp the “typical application”
    - Understand why the “hello world” board needs the included components
- Understand the:
    - difference between analog/digital
    - pinout / connection points

        - power requirements
        - how to drive / control / talk to device
- Be able to troubleshoot problems
        - what are the limitations, parameters?

Documentation Required for Completion:

At Minimum (electronics beginners):

- Fabricate the “hello world” input example board(s)
- Program them in as many languages as possible
- Make as many output boards as possible and thoroughly understand how they work.
- Document:
        - each board created/device used
        - what it does
        - what protocol it uses
        - what you learned

Students with Previous Electronics Experience

- Above requirements, plus….
- Design your own output board(s)
- Provide the design files
- Use new and output devices

What’s the Point?

If the beginner student doesn’t understand how the output device works and how talk to it, plus the additional components needed for the “typical application” to get the proper data out then ...

- That student will never progress to designing their own boards for their final project.
- **The temptation to use an Arduino will be strong.**
- **Arduino use signals a “FAIL” on the part of the Academy and it’s Gurus.**
- We need to facilitate learning and the weekly cycle is short.

COMPOSITES

Skills Acquired (similar to mold making):

- Designing 3D fabricatable CAD model for moldmaking
- Machining 3D files
- Learning about material safety
        - Read the Material Safety Data Sheet (MSDS)
        - Dangerous dust for lungs (Foam)
        - Respirators may be required
        - Protective clothing, ventilation, etc

        - Chemical properties, especially temperature!
    - Basic knowledge of mold releases
    - Understanding different types of casting materials and their properties
    - Demolding procedures

Documentation Required for Completion

- Large 3D mold designed (~ft_2), CAD files provided
- Mold machined
- Composite part(s) cast
- Document process, tooling, materials, machine and feeds & speeds used (if feeds & speeds applicable)

EMBEDDED NETWORKING AND COMMUNICATIONS

Skills Acquired:

- An understanding multi-node communication
- A grasp the concept of "addressing" and execute it
- Gett microcontrollers to talk back and forth.
- Understanding the differences between:
    - Synchronous vs asynchronous communication
    - Broadcasting vs addressing individual node
- Basic knowledge of common serial data standards:
    - RS-232
    - I2C, TWI
    - SPI
    - USB

Documentation Required for Completion:

At Minimum (electronics beginners):

- Fabricate the "hello world" networking example board(s)
- Program them in as many languages as possible
- Document:
    - each board created/device used
    - what it does
    - what protocol it uses and how it works
    - what you learned

Students with Previous Electronics Experience

- Above requirements, plus….
- Design your own networking board(s)
- Provide the design files
- Use new and unfamiliar protocols

INTERFACE AND APPLICATION PROGRAMMING

Skills Acquired:

- Learn about and be able to define and create and application
- Able to use an application to get data in and/or out of a computer
- Control and/or get data from something
- Write/modify an interface to work with an input or output device

Documentation Required for Completion:

- Write or modify an application that interfaces with an input and/or output device.
- Provide your code files in the original format
- Code must be executable (screenshots of code without files will not be accepted)

What's the Point?

Students won't get far with input, output devices and machines if they can't create basic applications to control them or visualize their data.

MECHANICAL AND MACHINE DESIGN

Skills Acquired:

- A rudimentary understanding of mechanical design and machine design
- Being able to identify basic mechanical components
- An basic understanding of:
    - how the components go together to create a machine
    - how to drive a machine
- Ideally every student builds one MTM(m) stage
- Realistically students participate in a group machine build led by the local instructor

Documentation Required for Completion:

- Participate in a group machine build
- Student documents their participation:
    - overall concepts learned
    - troubleshooting steps

        - tips for improvement
        - etc
- **Instructors must rate student participation**
    - Students who do not participate will not pass the unit

INVENTION, INTELLECTUAL PROPERTY, AND BUSINESS MODELS

Skills Acquired:

- Basic understanding of intellectual property:
    - copyright
    - patent
    - trademarks
    - income models
- Ideally, students have already posted a license on their website that covers all of their work created during the course.

Documentation Required for Completion:

- Student creates and documents a license for their final project
- Creates a plan for for sharing final project (dissemination)

DIGITAL FABRICATION APPLICATIONS AND IMPLICATIONS

Skills Acquired:

- learn about the wide range of different types of digital fabrication projects, applications of the subject matter and neat stuff in general.
- intellectual property/previous and helpful source documentation research skills
- basic project planning
- time management
- component selection
- sourcing components

Documentation Required for Completion:

Propose a final project that integrates the range of units covered.

- what will it do?
- who's done what beforehand?
- what materials and components will be required?

- where will they come from?
- how much will it cost?
- what parts and systems will be made?
- what processes will be used?
- what tasks need to be completed?
- what questions need to be answered?
- what is the schedule?
- how will it be evaluated?
- projects can be separate or joint, but need to show individual mastery of all of the skills

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DIGITAL FABRICATION PROJECT DEVELOPMENT

Skills Acquired:

- documentation during development
- demand- vs supply-side time management
- spiral development

Documentation Required for Completion:

- complete your final project
- track and document your progress:
    - what tasks have been completed, and what tasks remain?
    - what has worked?
    - what hasn't?
    - what questions need to be resolved?
    - what will happen when?
    - what have you learned?
- create a final project slide in the archive according to the specifications Bas provided.