

Edition 3 Revision 2 2011

**Be the
Combustion
of a
“Creative Explosion”**

This publication is compiled from many resources listed in the appendix and is meant to assist in the creation or operation of a Fab Lab.

This guide has presented the basic, very preliminary edition of the guide. It is hoped that the presented guide, even in its primitive form, will be useful to persons needing to develop and apply proven Fab Lab techniques. Of course, the Midwest Digital Fabrication Project participants itself needs fuller processing through all the updated equipment and techniques. Users and reviewers of this draft can facilitate the MDFP's further development and validation of the guide by sending in their corrections and suggestions. All such input will be appreciated and considered in the further development of the guide. The ultimate test of the guide will be its impact on helping academics and the develop and employing outstanding, life-changing and community Fab Labs.

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Fab Lab Basics

MIT Fab Lab

Center for Bits and Atoms

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Mission Statement

"The Fab Lab program is [the educational outreach] part of the MIT's Center for Bits and Atoms (CBA) which broadly explores how the content of information relates to its physical representation."

"The Fab Lab program has strong connections with the technical outreach activities of a number of partner organizations"

Fab Lab's mission is "for ordinary people to not just learn about science and engineering but actually design machines and make measurements that are relevant to improving the quality of their lives".

Background of Fab Lab

"In 2001 the National Science Foundation in Washington, D.C. funded MIT's Center for Bits and Atoms (CBA), an ambitious interdisciplinary initiative that is looking beyond the end of the Digital Revolution to ask how a functional description of a system can be embodied in, and abstracted from, a physical form."

"The Fab lab program was started in the Media Lab at MIT; it is collaboration between the Grassroots Invention Group and the Center for Bits and Atoms (CBA) at the Massachusetts Institute of Technology, broadly exploring how the content of information relates to its physical representation, and how a community can be powered by technology at the grassroots level. While the Grassroots Invention Group is no longer in the Media Lab, The Center for Bits and Atoms consortium is still actively involved in continuing research in areas related to description and fabrication but does not operate or maintain any of the labs worldwide (with the exception of the mobile Fab lab)." http://wapedia.mobi/en/Fab_lab

CBA's laboratory research on technologies for personal fabrication is complemented by the field "Fab Lab" program that brings prototyping capabilities to underserved communities that have been beyond the reach of conventional technology development and deployment.

Since local communities themselves foster innovation, it can lead to sustainable solutions. High-end technological solutions have not been addressing problems faced on the local level as yet; therefore, we believe Fab labs will provide a thriving incubator for local micro-businesses.

Fab Labs exist in Places such as:

- Rural India
- Northern Norway
- Ghana
- Boston
- South Bronx
- Costa Rica
- Ohio
- Wisconsin
- Washington D.C.
- Kansas

Outreach opportunities are currently being explored in countries such as

- Panama
- Trinidad
- South Africa
- And with institutional partners such as
- The National Academies
- The Indian Department of Science and Technology
- The Africa-America Institute

What is a Fab Lab?

"Fab Lab is an abbreviation for Fabrication Laboratory."

"It is a group of off-the-shelf, industrial-grade fabrication and electronics tools, wrapped in open source software and programs written by researchers at the Center for Bits and Atoms."

A Fab lab is interactive, hands-on, and do-it yourself.

"MIT has additionally written a Computer-Aided Machinery (CAM) program that can read all of the different kinds of ways that people describe things digitally and turn them into tool paths for all of the different ways it's possible to make them. Researchers have written another program for Fab Labs which helps users share their files and experiences as they work, so that users can teach each other rather than relying on a fixed curriculum"

Some Components of a Fab Lab include:

- A laser cutter that makes 2D and 3D structures,
- A sign cutter that plots in copper to make antennas and flex circuits,
- A high-resolution milling machine that makes circuit boards and precision parts,
- A CNC ShopBot for milling and 3d cutting and carving of wood and other materials,
- A suite of electronic components and programming tools for low-cost, high-speed microcontrollers

"A full Fab Lab currently costs about \$80,000 in equipment and materials without MIT's involvement."

What are the Fab Labs capable of?

The FabLab program falls under the Centre for Bits and Atoms (CBA) at the Massachusetts Institute of Technology. It is equipped with high-tech desktops, industrial-grade fabrication, electronics tools and software, which enables a child to create just about anything using methods ranging from desktop manufacturing to personal fabrication. It is a small-scale workshop equipped with the necessary tools to make almost anything.

The FabLab is a rapid prototyping platform and is meant to encourage local entrepreneurs, communities and learners to take their own ideas from the drawing board to prototypes in view of starting a local micro business, inventing a product or completing a class project. The FabLab also teaches users critical skills in computing, electronics, programming and CAD (computer-aided design) / CAM (computer-aided manufacturing) fabrication techniques – a set of internationally recognized skills. These skills have the potential to empower individuals to create for themselves smart devices that can be tailored to meet local or personal needs.

The FabLab allows its users around the world to locally conceptualize, design, develop, fabricate and test almost anything – for example, communication technologies are put within reach of almost anyone, almost anywhere.

There is a relationship between a FabLab and its contribution to maintaining child-friendly communities, with community engagement being the conduit. In order to understand the interrelationship, one needs to understand the definition of community engagement.

What is community engagement?

Community engagement (CE) is a two-way street where the school, the community and the families in that community actively work together creating networks of shared responsibility for the children's success. It is a tool that promotes civic wellbeing and strengthens the capacity of schools, families and communities to support the youth and ensure their optimal development. In this way, the FabLab is the hallmark of a community school.

At this point it would be prudent to discuss how the FabLab could be involved in the cognitive as well as the perceptual development of children. The Circle of Courage is a child development model, which this paper will discuss namely Belonging, Mastery, independence and Generosity, through which all children go as they grow into adulthood. The FabLab allows children to exploit these changes by giving them the opportunity to take ownership of a particular project. They then develop a sense of belonging in that the project belongs to them and they belong to the project, in turn giving rise to a sense of involvement and responsibility. It also affords the child the opportunity to master and develop skills in an age-appropriate manner. The model allows the children to work independently and to learn skills, attitudes, values and knowledge.

BENEFITS OF THE FABLAB FOR CHILDREN:

1. Exposes children to high-level technology
2. Inculcates a sense of belonging to the community
3. Develops creativity and innovation
4. Affords the community the opportunity to exploit individual / group talent.

Robert J. Sternberg states in the book in "How to develop student creativity", "The most powerful way to develop creativity in your students is to be a role model. Children develop creativity not when you tell them to, but when you show them."

The FabLab allows the child to experience innovation, discovery and creativity first hand.

Contribution of the FabLab to child development

Interactive play

Most often children play at the FabLab and in this way they develop both cognitively and perceptually. Play is vital in child development, as it allows for creativity while developing imagination, dexterity, and physical, cognitive and emotional strength. This results in healthy brain development. The play at the FabLab allows children at a very early age to engage and interact in the world around them by using the computers and interacting with others. In this way they master their world. Play helps children develop new competencies by realizing that they are capable of bigger and better things, which could lead to enhanced confidence and resilience when confronted with future challenges. This interactive stage enhances this sense of belonging.

(<http://pediatrics.aappublications.org/cgi/content/full/119/1/182>)

BELONGING

The child feels wanted and secure and experiences a sense of belonging. All of us have the need to feel valued, important, and protected by others. The need to feel comfortable and welcomed within a group – family, friends and colleagues – is important. The family and close community are the most important influences on the original development of this area of self-esteem. The sense of belonging greatly influences friendships and relationships.

Risk-taking

The FabLab allows children to take risks, and therefore their creativity and urge to innovate and explore are greater. The FabLab allows the child to develop creativity from intrinsic pleasure. The use of technology in the FabLab is “developmentally appropriate”. Very young children are taught to be comfortable and confident around computers. They follow instructions easily and use visual cues to understand and think about their activity (Clements & Nastasi 1993). Typing and working on the keyboard does not seem to cause them any trouble; if anything, it is a source of pride.

(<http://www.project2061.org/publications/earlychild/online/experience/clements.htm>)

Developing identity

In order to develop an identity the child needs to display confidence. The FabLab provides opportunities for the child to explore and develop his/her identity through creativity and innovation.

During this stage the child experiences the urge to do something, to complete something, and to experience the pleasure this brings coupled with the coming together of mental and physical capabilities. The FabLab facilitates the use of the child’s mental and physical capabilities and allows the child to move successfully onto the next stage of development.

MASTERY

By risk taking and fulfilling the sense of curiosity at the FabLab the child develops a sense of mastery and thus develops competence, seeks additional skills and knowledge, and is willing to try again if not successful the first time.

Discipline

At the FabLab, children are encouraged to work as individuals and in teams in order to learn to share, negotiate and resolve conflicts. Negotiating and decision-making skills are developed. The FabLabs allows for the children’s emerging areas of interest and career paths through social, emotional, physical and ethical behaviors. Neil Gershenfeld, in his book *Fab: The coming revolution on your desktop from personal computers to personal fabrication*, writes:

“Here they have the potential to vastly expand the creative powers of tinkerers and usher in a revolution in do-it-yourself design and manufacturing that can

empower even the smallest of communities. If you give people access and means to solve their own problems, it touches something very, very deep... Somehow it goes back to nest-building, or mastering your own environment. There's sort of this deep thing inside that most people don't express that comes tumbling out when they get access to these tools."

INDEPENDENCE

By allowing children to unleash their potential, they take control of themselves, their behavior, and their lives. A well-developed sense of autonomy and responsibility is ingrained when the FabLab affords children an ideal environment to become independent.

GENEROSITY

The FabLab inculcates in children a sense of generosity. They willingly share ideas and exchange views on projects and models in which they want to engage. An experience at the Fab Lab inculcates in learners a sense of Generosity. There exists opportunities to willingly share ideas and exchange views on projects and models that they would like to create. The staff at these Fab Labs encourages this generous culture of sharing and caring.

Even Erickson the famous psychologist makes reference to Cognitive and Aesthetic needs. The Fab Lab provides this wonderful experience in a caring environment to meet these needs so that our charges develop towards Self Actualization.

Children acting as links to older members of the family and community

Children working at a FabLab become *au fait* with the scope of the lab and are able to inform older members of the family and community on the potential of the FabLab. This is especially helpful to the not-so-literate community members who are often gifted in craft-making and spend copious amounts of time designing and producing their crafts. The FabLab helps them to create more crafts and get their money's worth from their products, thus bringing about symbiosis. Natural talent in craft-making, which is often traditional, can be passed on to children from adults. This also strengthens the bond between the older and younger members of the community.

Diversity

The FabLab recognizes the strengths and opportunities that are inherent in a diverse community. By participating in the FabLab, one learns about the values, skills and dreams of the other attendees' families and home cultures. By identifying and reaching out to children in this way, we will enable them to recognize resources and strengths where once they saw only deficits, weaknesses or faults. This is especially true in communities where there is little racial tolerance.

“DON'T IGNORE THE ELEPHANT IN THE ROOM “

“We all should know that diversity makes for a rich tapestry, and we must understand that all the threads of the tapestry are equal in value no matter what their color.” Maya Angelou

The FabLab allows one to acknowledge and address issues of race and class and define diversity as strength, thus creating opportunities for honest conversations about differences from the earliest stages of vision-building. Experience has shown us those children of all races work side by side, oblivious of racial differences and languages spoken.

SAFE ENVIRONMENT FOR CHILDREN

The FabLab is a safe environment where children should be supervised while being allowed to work independently.

WHAT DOES THE FABLAB OFFER?

- Awareness – The child is exposed to the concept and different tools of the FabLab.
- Sense of technical empowerment – The child can reverse-engineer items such as T-shirts, circuit boards, magnets, etc.
- Training – Hands-on training is offered.
- Problem-solving – The child's ideas are implemented and technology-based projects created, which can lead to invention.

THE ROLE OF THE FAMILY WITH THE CHILD AS THE LINK

Family involvement is seen as a primary vehicle for academic improvement. Every family should actively participate in their children's life and become role models.

Families are children's first teachers and their most influential role models and motivators.

Children receive powerful messages from family-school relationships. However, communities experience barriers between the home and the community. A question to ask is:

What creates this barrier between the home and the community?

The following are points I would consider as factors contributing to the non-involvement of parents in a child's life:

- Negative experiences
- Language and cultural differences
- Issues of race and class

However, all these factors hampering parents' involvement in the lives of their children can be obviated by getting parents involved in the FabLab experience. Therefore it can be safely stated that the FabLab provides a voice or an outlet for children's creativity and their right to participate in family, community and social life. The FabLab also provides a safe environment for children that is child centered and which takes a holistic approach to child development.

The FabLab does make a difference in the lives of children, in the sense that the children:

- Feel safe
- Are treated with respect
- Learn something new and gain skills
- Have the opportunity to join in and participate in activities
- Are involved in decision-making and planning that impacts on them and
- Have fun.

SELF-ACTUALIZATION

Once the child has transcended through all the stages, he/she attains the level of self-actualization, which is an essential ingredient for enduring motivators or

drivers of behavior. Self-actualization is the instinctual need of humans to make the most of their abilities and to strive to be the best they can be. According to Maslow's hierarchy of needs, the final stage of psychological development comes when the individual feels assured that his/her needs in terms of physiology, security, affiliation and affection, self-respect, and recognition have been satisfied. As these become dormant, he/she becomes filled with a desire to realize his/her potential to be an effective, creative and mature human being.

In short, self-actualization means reaching one's fullest potential. According to Maslow, "Self-actualizing people, those who have come to a high level of maturation, health and self-fulfillment, have so much to teach us that sometimes they seem almost like a different breed of human beings." (http://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs)

The Fab Lab should be considered as an important development which when used effectively can bring about unimaginable success stories.

CONCLUSION

To help all children succeed, **communities** must pay special attention to the multiple dimensions of young people's lives. Direct attention must be paid to other factors that influence the development of young people – including physical, social, and emotional health, as well as a motivating, engaging and safe environment with full family and community support.

Building child-friendly communities through the FabLab constitutes a cherished part of childhood that offers children important developmental benefits and parents the opportunity to fully engage with their children. Every community should strive to create the optimal developmental situation for children, by taking cognizance of all facets of a child's development and ensuring that safe environments are made available for all children.

In conclusion, I would like to reiterate the words of Sue Maguire, principal of Mount Anthony Union High School in the USA: *"Kids are part of a family and families are a part of a community. We don't work in isolation. It's common sense."*

(http://www.naesp.org/client_files/CommunityAndFamilyEngagement.pdf)

How have Fab Lab's helped people and communities?

Fab Labs have been called "Open Source Hardware" Dr Neil Gershenfeld, Director of The Center of Bits and Atoms, says: "By personal fabrication, what I mean is ordinary people creating, rather than consuming, technology, creating technology to solve local problems."

Fab Lab also teaches users Critical Skills in

- Computing
- Electronics
- Programming
- Invention
- Innovation
- Creative Thinking

As well as

- CAD/CAM fabrication techniques--a set of internationally recognized skills.

"It is a rapid prototyping platform, and as such is meant to encourage local entrepreneurs to take their own ideas from the drawing board to prototypes to starting local micro businesses"

It is additionally a platform from which a community's technical challenges can be shared with an international roster of engineers, who can help problem solve and design solutions for the community. In return for the involvement of trained engineers with the community, engineers have an opportunity to work on real life design problems faced by large, under-served communities at the lower end of the consumer market

Example 1:

Currently Fab Lab partners are working on creating mesh wireless, ad hoc networks in the Lyngen Alps of Norway to allow shepherds to keep track of their flocks from afar, and to allow fishermen to keep track of their boats at sea. At the Ghana Fab Lab, situated at the Takoradi Technical Institute, students are working on low-cost designs for mobile refrigeration and TV antennas. In Pabal, India Fab Lab users are making replacement gears for out-of-date copying machines, reliable tools for testing milk content and for diagnostics on human blood. At the Costa Rica Fab Lab young people are learning basic electronics and fabrication - by making functional objects with an array of sensors and actuators. In Boston Fab Lab users make jewelry, toys and crafts using recycled materials from the community.

Example 2:

"Sustainable" South Bronx's newest program was established through a partnership with MIT and serves as an incubator for green manufacturing and design. According to Craytor, "These FabLab gives people the opportunity to visualize and create solutions to problems that their communities have. We are using it to think about waste and how to reuse it. The FabLab has generated furniture made out of recycled wood and cardboard, and is working to create environmental monitoring devices.

"The projects are picked by the community based on urgency of needs and/or group interests. All the labs have the same equipment and capabilities so it is possible to share digital designs and fabricated solutions between labs, forming a network of intellectual property and idea exchange."

Example 3:

Fox Valley Technical College is leading the charge in bringing invention and innovation back to the forefront of their community. In just a short time they have had over 300 inventors go through the Fab Lab culminating in five patents, three applied for and over \$80,000.00 in economic impact in the community as of June 2010.

Sherry lassiter

Sherry Lassiter is the program manager for the Center for Bits and Atoms as well as the MIT Media Lab and The MIT Fab Lab. Prior to working for MIT; Sherry Lassiter was a former science documentary television producer, writer, director for 18 years. She has been with the Fab Lab at MIT since its inception. She runs the Fab Lab international network and also has worked in fabrication laboratory environments herself.

The Fab Charter

Mission: Fab labs are a global network of local labs, enabling invention by providing access for individuals to tools for digital fabrication.

Access: you can use the Fab lab to make almost anything (that doesn't hurt anyone); you must learn to do it yourself, and you must share use of the lab with other uses and users

Education: training in the Fab lab is based on doing projects and learning from peers; you're expected to contribute to documentation and instruction.

Responsibility: you're responsible for:

- Safety: knowing how to work without hurting people or machines
cleaning up: leaving the lab cleaner than you found it
operations: assisting with maintaining, repairing, and reporting on tools, supplies, and incidents
- Secrecy: designs and processes developed in Fab labs must remain available for individual use although intellectual property can be protected however you choose
- Business: commercial activities can be incubated in Fab labs but they must not conflict with open access, they should grow beyond rather than within the lab, and they are expected to benefit the inventors, labs, and networks that contribute to their success.

Why a Fab Lab?

Fab Labs provide widespread access to modern means for invention. They began as an outreach project from MIT's Center for Bits and Atoms (CBA). CBA assembled millions of dollars in machines for research in digital fabrication, ultimately aiming at developing programmable molecular assemblers that will be able to make almost anything. Fab Labs fall between these extremes, comprising roughly fifty thousand dollars in equipment and materials that can be used today to do what will be possible with tomorrow's personal fabricators.

Fab Labs have spread from inner-city Boston to rural India, from South Africa to the North of Norway. Activities in Fab Labs range from technological empowerment to peer-to-peer project-based technical training to local problem-solving to small-scale high-tech business incubation to grass-roots research. Projects being developed and produced in Fab Labs include solar and wind-powered turbines, thin-client computers and wireless data networks, analytical instrumentation for agriculture and healthcare, custom housing, and rapid-prototyping of rapid prototyping machines.

The Fab Academy

The Fab Academy provides instruction and supervises investigation of mechanisms, applications, and implications of digital fabrication.

Just as communications and computation went from analog to digital, resulting in PCs and the Internet, the digitization of fabrication is leading to personal fabricators that will allow anyone to make almost anything, anywhere. The development of digital fabrication is based on creating codes that don't just describe things; they are things, such as proteins are coded in molecular biology. This research roadmap is ultimately aiming at a Star Trek-style replicator, but prototype versions of these capabilities are already available in field "Fab labs".

Fab labs began as an outreach project from MIT's Center for Bits and Atoms (CBA), and spread around the world. The Fab Academy was launched to provide local access to global instruction for students in these labs who were exceeding available educational resources. It links students and faculty in Fab labs, with online video and collaborative content. Unlike remote instruction from a central campus, the digital fabrication tools in a Fab lab effectively allow the campus to come to the

student, for distributed rather than distance education.

The Fab Academy offers Certificates on relevant technical topics, and a Diploma aimed at vocational and technical training for employment and investment (along with assistance to its graduates in those areas). These are accredited by the Fab Academy; it is anticipated that they will be followed by a Bachelor's degree to be offered under applicable regional accreditation, along with post-graduate study.

Fab Academy Certificates provide familiarity with technical options and capabilities, hands-on experience, and direction for further study. Each requires, and is evaluated by, developing and documenting projects. They are periodically renewed to reflect best practices.

The Certificates typically require 1-2 weeks. They are combined in the Diploma, which is roughly comparable to completing MIT's rapid-prototyping course "How to Make *almost* Anything". It requires about 1 year, with progress evaluated by skills and projects rather than time or credits.

The Fab Academy Certificate topics that comprise the Diploma are:

- Foundations Of Digital Fabrication, Technical Background, Laboratory Safety
- Design Principles And Practices, Cad, Cam, Cae
- Computer-Controlled Cutting
- Computer-Controlled Machining
- Materials Selection, Production, Assembly, And Characterization
- 3d Molding And Casting
- 3d Scanning And Printing
- Electronics Design And Fabrication
- Embedded Programming
- Interface And Application Programming
- Sensors, Actuators, And Displays
- Embedded Networking And Communications
- Rapid-Prototyping Of Rapid-Prototyping Machines

- Collaborative Technical Development And Project Management
- Invention, Intellectual Property, And Business Models
- Digital Fabrication Applications And Implications
- Digital Fabrication Project Development

Following an initial trial in 2008, the Fab Academy will accept the first diploma students in the fall of 2009. Admission is limited by available space, and based on balancing the students' backgrounds, interests, and experience, as well as project portfolios. Fab Academy tuition is priced to cover the local costs of instruction, facilities, and materials, as well as global capacity. Where possible, support is sought for needs-based tuition assistance.

Common Equipment

Disruptive Innovation is Explosive!

Epilog Laser

<http://www.epiloglaser.com/>

Laser cutter

Depending on where you are in the world, you can buy one of these for \$16,000-\$27,000US. For US domestic purchases please contact Mark Schwarz at Epilog:

Mark Schwarz
Epilog Laser
303.277.1188
epiloglaser.com



Tell them you want to buy the “MIT Fab Lab” laser cutter. For the Laser cutter you will need some kind of ventilation or filter for the system. If you are unable to vent out of doors, you should order a Purex filter (Hepa filter). These are rather expensive -- approximately \$3,000. You should order this through your Epilog contact. If you plan to vent out of doors, you will need to order an exhaust system from Grizzly or Penn State or a dealer of your choice, Model DC5-5

Buy a gate for the exhaust so that you can control the amount of suction in the machine. This is particularly important when engraving or cutting light items, similar to Penn State PN # DB4, ABS plastic or aluminum N-BGAO4 (4 inch).

You will need the correct amount of tubing for your application, similar to Penn State PN D08 or D10PC. Don't forget to buy the clamps for the tubing. www.grizzly.com is another source that carries similar products. Also try Craftsman 3/4 hp Portable Dust Collector from Sears item #00921335000 Mfr. model #OR65000 at Sears.com.

ShopBot

PRStandard96 (96x48x-8in) with: \$12195.00-
\$609.75 (fablab discount)=\$11586.25
220V 4HP spindle: \$2619
Dust Collector: \$1200.00
Starter Bit Set: \$195.00



Roland Milling Machine

<http://www.rolanddga.com/>

1 MDX-20 milling machine 8"(X) x6"(Y)
x2-3/8"(Z) 10W 0.000246 in. /step
(0.00625 mm/step) 6500 rpm \$4,495



CAMM-1 Servo GX-24 Desktop

Vinyl Cutter

The **CAMM-1 Servo GX-24** uses a digital servomotor to achieve maximum accuracy and cutting speeds up to 20 inches per second. The desktop cutter also features a curve-smoothing function that allows precise cutting even at high speeds. The result is faster production and more professional-looking graphics.



Scroll Saw

1 DeWalt DW788S 20" Variable Speed
Scroll Saw with Stand and Light \$449.99



Clean Up

1 Black and Decker CHV9600 9.6-Volt
Cyclonic Dust Buster \$29.99



Mold Curing, Solder Reflow

1 Cuisinart TOB-175BC Convection Toaster Oven/
Broiler, Brushed Chrome \$178.85



Surface Mount Rework



1 Weller Heat Gun, Model 6966C, 750-
800 Degrees Fahrenheit \$115.85 for 220V version of the Weller Heat Gun,
please source locally, part #6966E.

Videoconference

1 Polycom V500 \$1,369.99

1 Coby TFTV1022 10.2-Inch Widescreen LCD
Color TV/Monitor \$159.37



Computers

5 HP Pavilion Slimline S3700F Desktop PC \$429.99
2.6 GHz AMD Athlon X2 5000 Dual-Core Processor
3 GB RAM, 320 GB Hard Drive, DVD Drive

Synaps 21.6" Widescreen LCD Monitor - 5ms
\$149.99 1680 x 1050, WSXGA+, 1000:1 Native,
DVI, VGA, Built-In Speakers



One computer is needed for each machine (Shop-Bot, Epilog, Modela, Camm), one for microcontroller programming, and more are recommended for design/education/collaboration.

The first consideration is the mission and purpose of your Fab Lab. This will influence your equipment and requirements. Please take time to talk to other Fab Lab's and review what they are doing and how they are doing it.

Fab Lab Capabilities

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Capabilities of the Fab Lab

Furniture Design

- Alternative modeling aids and scale models of design iterations
- Laser cut, CNC, and RP models
- Vinyl Cutting
- Haptic interface modeling

Industrial Design

- Alternative modeling aids and scale models of design iterations
- Laser cut, CNC, and RP modeling
- Vinyl Cutting
- Haptic interface modeling
- VR modeling

Interior Design

- Alternative modeling aids and scale models of design iterations
- Virtual Reality imaging
- Laser cut and CNC models
- Vinyl Cutting

Metals/Jewelry Design

- Alternative modeling aids and scale models of design iterations
- Computer Aided Design and Visualization
- Casting Pattern Generation through +/-RP/model making
- Part production via CNC/Laser cutting
- Materials/Processes Laboratory

Graphic Design

- Laser Cutting for Package Design
- CNC and RP for Package Design
- RP for Digital Media - Character/object models

Illustration

- 3D Animation/character/scene model making with Laser, CNC, RP
- Furniture and Functional Art
- CNC cutting using small and large scale machines (lg not yet acquired)
- Casting Patterns for hardware using RP

Photography

- Laser cutting/marking of prints
- Cintiq for digital manipulation of images

Art Education

- Painting, Drawing, and Printmaking
- Laser, CNC woodcuts
- Laser burning on paper substrates
- Cintiq digital painting and drawing input

Fab Labs are different than the myriad other nonprofit programs working to introduce technology to disadvantaged communities. The MIT professors who came up with the Fab Lab concept believed that rural villagers in India, sheep herders in Norway, and impoverished teens in this Pretoria township of Shoshanguve - anyone anywhere, really - could learn to create technology, as well as use it.

The labs are part of what the Center for Bits and Atoms believes is a trend toward widespread personal fabrication. This is the idea that, not long from now, individuals will be able to manufacture goods at home in the same way they now use

personal computing - they will be able to "print" a bicycle, for instance, or open a computer file that contains a piece of machinery.

The Fab Labs are filled with modern manufacturing equipment - laser cutters that can make two- and three-dimensional structures; copper cutters that make circuit boards and antennas; plasma cutters to model steel and aluminum. They have open-source computer codes for new inventors to design their projects; and various print and online manuals for newcomers to teach themselves how to create.

The labs also show how personal fabrication can empower communities, Lassiter says. Once people learn the basics of the Fab Labs' computers and manufacturing equipment, they can start developing their own solutions to local problems.

In June of last year, MIT helped open a Fab Lab near the University of Pretoria, in a new science park called the Innovation Hub. Soon after, the government decided to open three more labs at about \$25,000 each with the idea of eventually creating a countrywide fabrication laboratory network. In February, the first township Fab Lab opened in Shoshanguve.

The high concept is to get these into the communities, a government program created to spread science and technology. "It's the idea that if you're somewhere in rural South Africa, and you want something for solar energy, you can go to a Fab Lab and make your own."

Meanwhile, he says, the labs can help excite a new generation of South Africans about manufacturing - an underdeveloped economic sector here. He says the labs might also spark new businesses, even industries, by allowing inventors of all backgrounds to use equipment and design prototypes for free.

This is the hope in Shoshanguve, a sprawling township of squatter shacks and small brick houses 30 miles north of Pretoria. "Unemployment is high here, so is poverty," says David Rafapha, who works in the new Shoshanguve Fab Lab. "We are about educating young people, getting kids to come into the Fab Lab and come up with ideas that can sustain their lives."

Already, Mr. Rafapha said, one person working in the Shoshanguve Fab Lab has designed a device that lets a person control the light switches in his or her house with a cell phone - a security tool that could help, and would have a market, in this high-crime area.

Meanwhile, dozens of children are getting their first taste of technology.

The Shoshanguve Fab Lab is located within a single room, next door to a health clinic and across the street from a handful of shipping containers converted into shops. There are seven computers, a few desks, and some rolling chairs. The machinery is crammed into the corners.

The lab is most crowded when school lets out. When it first opened, it had a first-come, first-served policy. But the demand for machines became so huge that the staff put time limits on the computers and reserved weekly time slots for younger children and older adults.

Justinos Nkutshwev is one of the regulars. He sits at a computer, using the mouse to manipulate lines on a graphics program. He is building a bus, he says, and a generator to make it run. He is 15 years old and never used a computer before he came to the Fab Lab a few months ago. Now, he works with the lab's machines twice a week. "I come here because I can make interesting things," he says.

Although the lab technically closes at 5 p.m., the staff regularly keeps it open later. Sometimes teenagers show up at staff members' houses on Sunday, begging them to unlock the doors.

"They say 'We need to finish our projects, can you please open?' "Nkadimeng says."It's great to see them so eager. There's no way to say no."

Network Equipment And Software

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Polycom PVX 8.0 software

Polycom PVX 8.0 Part # 5151-22710-001

The Polycom PVX extends the ultimate Polycom video conferencing experience to your PC and webcam with the first software application ever offered. The Polycom PVX works in conjunction with your PC and USB camera to provide the highest quality video and audio experience in the industry. Add the Polycom PVX to your PC and within minutes you'll be talking, via video, to customers and colleagues around the world. The Polycom PVX solution is an easy way to communicate face-to-face from your office, from your home or on the road.

The latest version of Polycom PVX includes improvements to SIP interoperability and stability, the ability to specify CPU resources for the webcam and Universal Plug and Play support for secure firewall transversal calls with enabled routers.

Polycom PVX 8.0 Part # 5151-22710-001

SUPPORTED FEATURES

- People + Content support
- H.264 support
- TV quality video at 384Kbps
- SIP support
- H.323 support

Ekiga (GPL)

Ekiga is a SIP and H.323 compatible VoIP, IP Telephony, and Video Conferencing application that allows you to make audio and video calls to remote users with SIP or H.323 hardware and software. It supports all modern VoIP features for both SIP and H.323. Ekiga is the first Open Source application to support H.323 and SIP, as well as audio and video. Ekiga was formerly known as Gnome Meeting.

Ekiga is licensed under the GPL license and as a special exception, you have permission to link or otherwise combine this program with the programs OPAL, OpenH323 and PWLIB, and distribute the combination, without applying the requirements of the GNU GPL to the OPAL, OpenH323 and PWLIB programs, as long as you do follow the requirements of the GNU GPL for all the rest of the software thus combined.

You will need:

- A correctly configured firewall and NAT router/gateway (see this FAQ for more information).
- You don't need a webcam. Ekiga is primarily VoIP software.
- Having a headset is recommended if you want to prevent echo. However, a webcam with an internal microphone or a separate microphone will also work.

NetMeeting (Windows)

Microsoft NetMeeting is a VoIP and multi-point videoconferencing client included in many versions of Microsoft Windows. It uses the H.323 protocol for video and audio conferencing, and is interoperable with OpenH323-based clients such as [Ekiga](#), and Internet Locator Service (ILS) as reflector. It also uses a slightly modified version of the ITU T.120 Protocol for [white boarding](#), application sharing, desktop sharing, remote desktop sharing (RDS) and [file](#) transfers. The secondary [White-board](#) in NetMeeting 2.1 and later utilizes the H.324 protocol.

- NetMeeting also uses H.263 standard for IP/Ethernet LAN multimedia conferencing:
 - Audio codec uses ITU G.723 standard and offers bit-rates between 4.8 Kbit/s and 64 Kbit/s.

- Video codec uses ITU H.263 standard and supports 30 fps.
- NetMeeting audio and video codec's use RTP above UDP/IP connections.
- Whiteboard, Chat, and File Transfer use ITU T.120 Data Conferencing standard above TCP/IP connections.

TightVNC

TightVNC is a cross-platform open source remote desktop software application that uses and extends VNC's RFB protocol to control another computer's screen remotely. It contains extensions that provide for 'tight encoding', which improves performance over low bandwidth connections

TightVNC is cross-compatible with other client and server implementations of VNC; however, tight encoding is not supported by most other implementations, so it is necessary to use TightVNC at both ends to gain the full advantage of its enhancements.

Among notable enhancements are file transfers, support for Windows DFMirage mirror driver to detect screen updates (saves CPU time).

Video Streaming:

Streaming media is [multimedia](#) that is constantly received by, and normally presented to, an [end-user](#) while it is being delivered by a streaming provider. The name refers to the delivery method of the medium rather than to the medium itself. The distinction is usually applied to media that are distributed over [telecommunications networks](#), as most other delivery systems are either inherently streaming (e.g. [radio](#), [television](#)) or inherently non-streaming (e.g. [books](#), [video cassettes](#), audio [CDs](#)).

Settings:

- <http://mcu.cba.mit.edu/>
- Conference ID: 1 for the Fab Lab videoconference

Appendix

Miscellaneous Supplies

Techni-Tool <http://www.techni-tool.com>

1 471TE2110/SFG-2110/Instek Function Generator, 10 MHz DDS with Counter/\$420.00

1 471TE3303/GPS-3303/Instek Power Supply, Triple Output, DC, Digital, 30V, 3A/\$420.00

1 471TE821/GDS-820C/ Instek Digital Storage Oscilloscope, 150 MHz, Color/\$1295.05

1 516IN346/ Luxo Magnifier Light, IFM,5 DIOPTER, 45" ARM, CLAMP-ON/\$107.90

3 516IN640/ Luxo Magnifier Lamp Replacement bulbs /\$13.00 \$39.00

*** These can be ordered in a 220V/50Hz configuration. For 220V/240V test equipment please contact: Fotronics Inc. (www.testequipmentdepot.com) they will convert these items to 220V for you. Phone: Tel#781-665-1400 or 800-517-8431.*

****The Luxo Magnifier Lamp can be purchased in 220V from Techni-tool (call them) or sourced locally. Part#16912, KFM series, 5 diopter, 45" Arm, Clamp-on. Cost is \$257.00 for 220V. The replacement bulbs are the same as listed above.*

Digi-Key <http://www.digikey.com/>

Resistors

1,000 311-0.0ERCT-ND/RES 0.0 OHM 1/4W 5% 1206 SMD-\$0.01653/ \$16.53

100 PRL1632.100FCT-ND/RES .100 OHM 1W 1% 1206 SMD/\$0.36140/\$36.14

1,000 311-1.00FRCT-ND/RES 1.00 OHM 1/4W 1% 1206 SMD-\$0.01856/ \$18.56

1,000 311-4.99FCT-ND/RES 4.99 OHM 1/4W 1% 1206 SMD-\$0.01856/ \$18.56

1,000 311-10.0FCT-ND/RES 10.0 OHM 1/4W 1% 1206 SMD-\$0.01856/ \$18.56

1,000 311-49.9FRCT-ND/RES 49.9 OHM 1/4W 1% 1206 SMD-\$0.01856/ \$18.56
1,000 311-100FRCT-ND/RES 100 OHM 1/4W 1% 1206 SMD/0.01856/\$18.56
1,000 311-499FRCT-ND/RES 499 OHM 1/4W 1% 1206 SMD-\$0.01856/ \$18.56
1,000 311-1.00KFRCT-ND/RES 1.00K OHM 1/4W 1% 1206 SMD-\$0.01856/\$18.56
1,000 311-4.99KFRCT-ND/RES 4.99K OHM 1/4W 1% 1206 SMD/\$0.01856/\$18.56
1,000 311-10.0KFCT-ND/RES 10.0K OHM 1/4W 1% 1206 SMD-\$0.01856/\$18.56
1,000 311-49.9KFRCT-ND/RES 49.9K OHM 1/4W 1% 1206 SMD-\$0.01856/\$18.56
1,000 311-100KFRCT-ND/RES 100K OHM 1/4W 1% 1206 SMD/0.01856/\$18.56
1,000 311-499KFRCT-ND/RES 499K OHM 1/4W 1% 1206 SMD/0.01856/\$18.56
1,000 311-1.00MFRCT-ND/RES 1.00M OHM 1/4W 1% 1206 SMD-\$0.01856/\$18.56
1,000 311-4.99MFRCT-ND/RES 4.99M OHM 1/4W 1% 1206 SMD-\$0.01856/\$18.56
1,000 311-10.0MFRCT-ND/RES 10.0M OHM 1/4W 1% 1206 SMD-\$0.01856/\$18.56

Capacitors

<http://fab.cba.mit.edu/about/fab/inv.html>

500 311-1212-1-ND/CAP CERAMIC 1PF 50V NPO 1206-\$0.04200/\$21.00
500 311-1150-1-ND/CAP CERAMIC 10PF 50V NPO 1206-\$0.03612/\$18.06
500 311-1161-1-ND/CAP CERAMIC 100PF 50V NPO 1206-\$0.04200/\$21.00
500 311-1144-1-ND/CAP 1000PF 1KV CERAMIC X7R 1206-\$0.15300/\$76.50
500 311-1174-1-ND/CAP 10000PF 50V CERAMIC X7R 1206 \$0.03360/\$16.80
500 399-4674-1-ND/CAP CERAMIC .1UF 250V X7R 1206/0.13126/\$65.63
250 PCC2234CT-ND/CAP 1.0UF 50V CERAMIC F 1206/0.15180/\$37.95
1,000 311-1196-1-ND/CAP 3.3UF 16V CERAMIC Y5V 1206-\$0.06080/ \$60.80
100 587-1352-1-ND/CAP CER 10UF 35V Y5V 1206/0.20800/\$20.80
10 589-1002-ND/CAPACITOR ULTRA 10F 2.7V RADIAL/\$3.24500/\$32.45

Chokes

25 PCD2144CT-ND/CHOKE COIL 1.2UH 6500MA SMD/1.62800/\$40.70
25 PCD2152CT-ND/CHOKE COIL 10UH 3900MA SMD/1.62800/\$40.70
25 PCD2164CT-ND/CHOKE COIL 100UH 1200MA SMD/1.62800/\$40.70
25 PCD2176CT-ND/CHOKE COIL 1000UH 410MA SMD/1.62800/\$40.70

Diodes

500 497-5559-1-ND/DIODE SCHOTTKY 100V SGL SOD-123/0.15360/\$57.60
500 BZT52C3V3-FDICT-ND/DIODE ZENER 500MW 3.3V SOD123/\$0.12/\$60.00
500 BZT52C4V7-13-FDICT-ND/DIODE ZENER 4.7V 500MW SOD-123/\$0.12/\$60.00

Transistors

250 NDS355ANCT-ND/MOSFET N-CH 30V 1.7A 3-SSOT/\$0.29700/ \$74.25
250 NDS356APCT-ND/MOSFET P-CH -30V +1-1.1A 3-SSOT/\$0.33750/ \$84.38
50 FDC796NCT-ND/MOSFET N-CHAN 30V 12.5A 6SSOT/0.87500/\$43.75
50 ZXMH3A01T8CT-ND/MOSFET H-BRIDGE DUAL SM-8/\$2.53800/\$126.90

Regulators

250 LM3480IM3-3.3CT-ND/IC 3.3V100MA LDO VREG SOT23/\$0.43500/\$108.75
250 LM3480IM3-5.0CT-ND/IC 5.0 100MA LDO VREG SOT23/\$0.43500/\$108.75
100 LM2940IMP-5.0CT-ND/IC 5V 1A LDO VREG SOT223/\$1.17640/\$117.64

LEDS

250 160-1167-1-ND/LED RED CLEAR 1206 SMD/\$0.07600/\$19.00
250 160-1169-1-ND/LED GREEN CLEAR 1206 SMD/\$0.07000/\$17.50
100 441-1009-ND LED MINI WEDGE WHITE WATER CLEAR/\$1.06600/\$106.60
100 475-1236-1-ND/LED RGB 4-PLCC SMD/0.61030/\$61.03
100 QED123-ND/LED IR EMITTING ALGAAS 880NM 5MM/0.23400/\$23.40

100 365-1148-1-ND/LED IR 880NM FLAT LENS 1206 SMD/0.26000/\$26.00

Photodetectors

100 QSD123-ND/IC PHOTOTRANS IR 880NM BLACK 5MM/0.23760/\$23.76

100 365-1155-1-ND/PHOTOTRANSISTOR NPN OPAQUE 1206/0.24000/\$24.00

100 365-1157-1-ND/PHOTOTRANSISTOR NPN CLEAR 1206/0.22000/\$22.00

Lcd

25 67-1781-ND/LCD MODULE 16x2 CHARACTER/\$4.88000/\$122.00

Speakers and Microphones

25 GC0351M-ND/SPEAKER 16X35MM 8 OHMS .5WATT/2.94000/\$73.50

50 423-1043-ND/MIC CONDENSER ELEC -40+-3DB PIN/1.68000/\$84.00

Thermistor

25 235-1109-1-ND/THERMISTOR NTC 10K OHM 10% 1206/2.26800/\$56.70

Op-Amp

100 AD8605ARTZREEL7CT-ND/IC OPAMP SNGL R-R I/O LN SOT23-5/1.00500/\$100.50

Microcontrollers

200 ATTINY45V-10SU-ND/IC AVR MCU 4K 10MHZ 8SOIC/1.18000/\$236.00

100 ATTINY44-20SSU-ND/IC MCU AVR 4K FLASH 20MHZ 14SOIC/1.42000/\$142.00

50 ATMEGA88-20AU-ND/IC AVR MCU 8K 20MHZ 5V 32TQFP/2.36000/\$118.00

Resonator

100 PX200BCT-ND/RESONATR CERM W/CAP 20.00MHZ SMD/0.48460/\$48.46

Buttons And Switches

50 401-1001-1-ND/SWITCH SLIDE SPDT 12V 100MA GW/\$1.03200/\$51.60

100 SW262CT-ND/SWITCH TACT SMD W/GND 160GF/0.54400/\$54.40

Magnets

100 469-1004-ND/MAGNET 1/4"DIA X 1/8"THICK/\$0.16880/\$16.88

100 469-1002-ND/MAGNET 1/2"DIA X 1/8"THICK/\$0.33750/\$33.75

Headers

10 ED23064-ND/CONN SOCKET 64POS.100 SMT/\$5.05700/\$50.57

10 ED2164-ND/CONN HEADER 64POS.100 R/ANGLE/\$5.71500/ \$57.15

Jacks and Plugs

100 CP1-023PJCT-ND/CONN PWR JACK DC 0.65X2.75MM SMD/\$0.44800/\$44.80

100 CP-012-ND/CONN DC PWR PLUG 0.7X2.35MM/\$0.60000/\$60.00

50 CP-002AHPJCT-ND/CONN/POWER JACK 2.1MM SMD/\$0.69900/\$34.95

100 CP-2501SP-ND/CONN PLUG STEREO 2.5MM W/COVER/\$0.64000/\$64.00

100 CP1-2533SJCT-ND/CONN JACK STEREO 3PIN 2.5MM SMD/\$0.46200/\$46.20

50 CP-1453-ND/CONN RCA PLUG W/STRAIN REL BLK/\$0.79300/\$39.65

10 SC1323-ND/CONN JACK PHONO 2POS SHIELDED/2.55000/\$25.50

Ribbon Cable and Connectors

25 HFPO9H-ND/CONN DB9 FEMALE PLASTIC SHELL/3.22400/\$80.60

25 HMP25H-ND/CONN DB25 MALE PLASTIC SHELL/4.05600/\$101.40

1 AE09M-300-ND/CABLE 9 COND 300' MULTI RIBBON/136.91000/\$136.91

Test Clips

5 923655-08-ND/8-PN GOLD SMD TEST CLIP/\$11.35000/\$56.75

Antistatic Bags

100 16-1032-ND/BAG ESD SHLD 3"X5" METAL-IN ZIP/\$0.08350/\$8.35

100 16-1034-ND/BAG ESD SHLD 5"X8" METAL-IN ZIP/0.16590/\$16.59

50 16-1036-ND/BAG ESD SHLD 8"X10" METAL-IN ZIP/\$0.40520/\$20.26

Heat Shrink Tubing

5 A116B-4-ND/HEATSHRINK 1/16 IN X 4FT BLACK/\$0.57600/\$2.88

5 A018B-4-ND/HEATSHRINK 1/8 IN X 4FT BLACK/\$0.65800/\$3.29

5 A014B-4-ND/HEATSHRINK 1/4 IN X 4FT BLACK/\$1.00000/\$5.00

5 A038B-4-ND/HEATSHRINK 3/8 IN X 4FT BLACK/\$1.11600/\$5.58

5 A012B-4-ND/HEATSHRINK 1/2 IN X 4FT BLACK/\$1.26000/\$6.30

Soldering

4 KE1409-ND/SOLDER NO-CLEAN .020" X 1 lb/\$24.75/\$99.00

1 K416-ND/FAN FUME ABSORBER BENCHTOP 115V/\$121.2900/\$121.29

10 EB1088-ND/QUICK BRAID GOLD .050" X 10'/\$3.37000/\$33.70

1 WES51-ND/SOLDER STATION ANALOG 50W/\$99.00000/\$99.00***

5 ETU-ND/TIP REPLACEMENT SINGLE FLAT.015"/\$5.12000/\$25.60

Tools

20 EROP7SA-ND/TWEEZER CURVED PRECISION TIP/\$2.49000/\$49.80

5 PAL1106.1-ND/WIRE STRIP/CUTTER P20 30-20AWG/\$11.49000/\$57.45

5 MS54-ND/PLIER DIAGONAL CUTTING/\$11.99000/\$59.95

5 L4-ND/PLIER SUBMINIATURE LONG NOSE/\$13.04000/\$65.20

10 243-1021-ND/MAGNIFIER EYE LOUPE 10X 1" LENS/\$1.80000/\$18.00

4 201PV-ND/PANAVISE JR. UNIVERSAL VISE/\$23.99000/\$95.96

2 XP600-ND SCREWDRIVER PRECISION SET 6 PC/\$21.03000/\$42.06

Battery Connections

100 BS6I-MC-ND/9V BATTERY SNAP WITH 2PC MOLDED/\$0.35000/\$35.00

50 BH9V-W-ND/HOLDER BATTERY 9V WIRE LEADS/\$0.79500/\$39.75

100 55K-ND/CLIP BATTERY AAA/N CELL SMT/\$0.12810/\$12.81

Multi-meter

3 PM51A-ND/DMM PKT W/FREQ & CAPACITANCE/3/\$28.95000/\$86.85

For labs requiring 220V:

** You will need to source this locally as this part is 110V

*** Welding Station: WES51DUK: 220V, 50Hz you will need to source this locally

Mouser <http://www.mouser.com>

Ribbon Cable Connectors

100 571-14453622/1445362-2/AMP MTA .050" Connectors/2P REC KIT,RIBN CBL 28 AWG/\$0.270/\$ 27.00

100 571-14453623/1445362-3/AMP MTA .050" Connectors/3P REC KIT,RIBN CBL 28 AWG/\$ 0.340/\$ 34.00

100 571-14453624/1445362-4/AMP MTA .050" Connectors/4P REC KIT, RIBN CBL 28 AWG/\$ 0.440/\$ 44.00

100 571-14453625/1445362-5/AMP MTA .050" Connectors/5P REC KIT, RIBN CBL 28 AWG/\$ 0.510/\$ 51.00

100 571-14451212/1445121-2/AMP MTA .050" Connectors/2P VERT PIN HDR, SMT Tin/\$ 0.560/\$ 56.00

100 571-14451213/1445121-3/AMP MTA .050" Connectors/3P VERT PIN HDR, SMT Tin/\$ 0.630/\$ 63.00

100 571-14451214/1445121-4/AMP MTA .050" Connectors/4P VERT PIN HDR, SMT Tin/\$ 0.700/\$ 70.00

200 571-14451215/1445121-5/AMP MTA .050" Connectors/5P VERT PIN HDR, SMT Tin/\$ 0.770/\$ 154.00

100 571-14451722/1445172-2/AMP MTA .050" Connectors/2P R/A PIN HDR, SMT Tin/\$ 0.520/\$ 52.00

100 571-14451723/1445172-3/AMP MTA .050" Connectors/3P R/A PIN HDR, SMT

Tin/\$ 0.560/\$ 56.00

100 571-14451724/1445172-4/AMP MTA .050" Connectors/4P R/A PIN HDR, SMT
Tin/\$ 0.630/\$ 63.00

100 571-14451725/1445172-5/AMP MTA .050" Connectors/5P R/A PIN HDR, SMT
Tin/\$ 0.760/\$ 76.00

Jameco <http://www.jameco.com>

Ultrasonic Transducers

10 139492/SENSOR,ULTRASONIC,40KHZ,TRAN(1),REC(1),112db/67db,2000pf/VARI-
OUS 40TR12B-R/\$6.96/\$69.60

Motors

10 238051 MOTOR,STEP,12VDC/.13A, 4deg,800GM-CM,120 JAMECO RELIAPRO
35BYJ01 \$3.91 \$39.10

10 171601 MOTOR,STEP,7VDC/20ohms UNIPOLAR,S/A 3.6deg,.08 D SHAF VARIOUS
NIPPON PF35T-48L4 \$1.95 \$19.50

10 237665 MOTOR,STEP,16.2VDC/.19A,40, 15deg,100GM-CM JAMECO RELIAPRO
25BY2407 \$2.55 \$25.50

10 232101 MOTOR,DC,12-24V,22600RPM,1.4A 88.5G-CM,20.6W,SHFT 02.3X13mm
JAMECO RELIAPRO MD5-1980AS-AA \$3.91 \$39.10

10 232005 MOTOR,DC,6-12V,9000RPM,0.6A 46.6G-CM,4.3W,SHFT 02X8mm JAMECO
RELIAPRO UC-280S-19160-R \$2.17 \$21.70

10 231757 MOTOR,DC,6-18V,6350RPM,0.3A, 20G-CM,1.4W,SHFT 02X9.6mm JAMECO
RELIAPRO PC-130SF-10315 \$2.29 \$22.90

10 253489 MOTOR,DC,GEAR,12V,56/1,110RPM, 1300G-CM,76MA JAMECO RELIAPRO
38-005 \$15.10 \$151.00

Power Supplies

10 249121/TRANS,WALL,24VDC/1150mA,F2,2.1mm X 5.5mm,UL/
CUL/\$21.10/\$211.00

10 143693/TRANS,WALL,9VDC/1.5A,F2,2.1mm X 5.5mm,UL/CSA/\$9.49/\$94.90

Test Leads

10 CABLE ASSEMBLY, RG174, BNC TO MICROHOOK/JAMECO BENCHPRO 05-A-081-R/11422/\$3.19/\$31.90

10 CABLE ASSEMBLY, RG174, BNC TO MINIHOOK/JAMECO BENCHPRO 05-A-078-R/11464/\$3.99/\$39.90

Coax Adapters

10 PLUG, BNC/BANANA/JAMECO VALUEPRO 03-701A-R/11440/\$5.39/\$53.90

10 BNC DOUBLE M TO BNC DOUBLE F/JAMECO VALUEPRO BJ-70823/207124/\$4.05/\$40.50

Third Hands

5 TOOL, THIRD HAND/VARIOUS 3RD HAND/26690/\$5.95/\$29.75

McMaster-Carr <http://www.mcmaster.com/>

Measuring

10 2388A71 Ss Pocket Rule Without Clip Or Depth Gauge Inch Decimal Graduations, 6" Length \$5.01 Each \$50.10

1 1760T86 Compact Digital Bench Scale with Ss Platform 2000 Grams X 0.1 Grams, 70.55 oz X .005 oz \$295.45

1 2289A45 Economy Dial Caliper 0-6" Range, .001" (.02mm) Graduations \$28.97

6 6839A75 High-Visibility Long Measuring Tape Inch/Metric Grads, 50'/15M X 3/8" Neon Orange \$12.39 Each \$74.34

Storage

2 5073T12 Cardboard Bin Box Standard, 2" W x 12" D x 4" H, 10 Pack; \$7.71/pk \$15.42

2 5073T29 Cardboard Bin Box Standard, 3" W x 12" D x 4" H, 10 Pack; \$10.57/pk \$21.14

2 5073T11 Cardboard Bin Box Standard, 4" W x 12" D x 4" H, 10 Pack; \$13.01/pk \$26.02

2 5073T14 Cardboard Bin Box Standard, 6" W x 12" D x 4" H, 10 Pack; \$9.98/pk

\$19.96

2 5073T15 Cardboard Bin Box Standard, 8" W X 12" D X 4" H, 10 Pack \$11.36/pk
\$23.82

4 9619T61 Plastic Drawer Cabinet 16 Small Polypropylene Drawers, 8-1/2" H Overall
\$8.84/ea \$35.36

1 9619T71 Plastic Drawer Cabinet 24 Large Polypropylene Drawers, 15-13/16" H
Overall \$22.36

Cutting

4 41865A-12 Scroll Saw Blade Regular Cut; .250" Width, .028" thk, 20 tpi, 12-pack
\$5.11/pk \$20.44

4 41865A-14 Scroll Saw Blade Fast Cut Skip Tooth, .029" W, .012" thk, 20 tpi, 12-
pack \$4.78/pk \$19.12

4 41865A-16 Scroll Saw Blade Fast Cut Skip Tooth, .100" W, .022" Thk, 9 Tpi, 12 pack
\$5.33/pk \$21.32

10 35545A71 Auto-Lock Breakaway-Blade Utility Knife Trimline w/Three 13-Point
Blades \$2.69 \$26.90

Molding And Casting

5 9389K61/Nonabrasive Machinable Wax Hard Purple Bar, 1-1/4" Thick X 3-1/2" W X
12" L/\$23.64 Each/\$118.20

2 1865T35 Plastic Cup Polypropylene, 2-1/2 oz, 2-3/8" Top OD X 1-5/8" H, Packs of
125 \$7.03 Pack \$14.06

1 77985T54 6" Length Wooden Paint Stirrer, Packs of 500 \$8.23 Pack \$16.46

2 52555T1 Nitrile Disposable Gloves Powder Free, 5 MIL Thick, 9-1/2" L, Large, Blue,
Boxes of 100 \$13.33 Box \$26.66

10 17805T81 Disposable Aluminum Weighing Dish Smooth Sides, 2-7/8" Diameter X
3/4" Depth, Packs of 100 \$8.72 Pack \$43.60

2 9060K53 Soft Tempered Aluminum Foil .001" Thick, 12" Width, 250' Roll \$27.26
Each \$54.52

Cable Ties

5 7134K21 Reusable Nylon Cable Tie Top Tab, 6" L, 1-1/2" Bundle Diameter, Off-White, Packs of 100/\$6.22 Pack/\$31.10

5 7134K61 Reusable Nylon Cable Tie Top Tab, 15" L, 4-1/4" Bundle Diameter, Off-White, Packs of 25/\$6.66 Pack/\$33.30

Hand Tools

5 4057A52 Maxi-Grip Magnetic Hand Driver Ratcheting; 2 ea Phil Slotted, Torx, SQ, Pozidrive \$15.45 \$77.25

3 8174A42 12-Piece Economy Needle-File Set 5-1/2" Long, Cut No.2 \$16.36 Set \$49.08

Glue Gun

1 7578A11 Cordless Glue Gun \$22.98

2 7518A717 Clear Glue Stick, 1/2" X 4", 1-lb Package \$6.61/pk \$13.22

Modela Collet Hex Key And Set Screw

5 5503A36 Ball-Point L-Key 1.5mm Hex, 3-5/64" Blade Length \$0.58/\$2.90

2 92605A097 Metric 18-8 SS Flat Point Socket Set Screw M3 Size, Packs of 25 \$4.40 Pack \$8.80

Lasercutter Cardboard

2 20855T66 Heavy Duty Corrugated Paperboard Carton 10 Pack \$16.26/\$32.52

Lasercutter Acrylic

5 8473K278 Preshrunk Clear Cast Acrylic Sheet 1/8" Thick, 12" X 24" \$34.20 \$171.00

Lasercutter Cleaning Swab

1 7074T62 Swab Cotton-Low Lint Tip, .141" Diam X .44" L Tip, 6" L O'all, 1000/pk \$18.75/ Pack

Magnet Wire

1 7588K71 Magnet Wire 30 AWG, Copper, 3000' Length Spool \$14.88 Spool \$14.88

Vinyl-Cut PCB Substrate

10 8525K411 Grade Xx Tan Garolite Sheet 1/32" Thick, 12" X 12" \$2.36\$23.60

Non-Skid Feet

1 6968T61 Textured-Surface Antislip Runner Mat Rubber, 36" W X 48" L, 3/32" Thick, Black, Pebbled Top \$19.78 Each \$19.78

US Gypsum <http://plaster.com/>

Casting

10 Hydrostone Super X - 1 Gallon Pail \$9.25 \$99.25

10 Drystone - 1 Gallon Pail \$9.75 \$99.75

Smooth-On <http://www.smooth-on.com/>

Molding

10 PMC-121/30 DRY - 2 lbs \$22.00 \$220.00

Blick Art Materials <http://www.dickblick.com/>

Molding

10 33523-1005 INSTAMOLD COMPOUND, 12OZ \$6.92 \$69.20

5 33504-1925 FLEXWAX MATERIAL, 2.5LB \$14.99 \$74.95

Budnick Converting <http://www.budnickconverting.com>

Vinyl cutter

Permacel # 595B transfer adhesive 6"x60 yds. @ \$41.04/roll

3M #214 masking tape 6"x60 yds @ \$140.60/roll

3M #1 epoxy film on liner 6"x100 yds @ \$181.76/roll

3M #1126 copper tape with conductive adhesive 6"x36 yds @\$236.44/roll

Vinyl rolls

beacongraphics.com

Vinyl cutter

(note this is "Sign" vinyl, 4 years durability, opaque, A4 series)

(A4120-O-F) A4 OPQU Can Yel 1550 (\$49.00)

(A4330-O-F) A4 OPQU Card Red 1550 (\$49.00)

(A4583-O-M) A4 OPQU Royal Blue 2450 (\$78.00)

(A4673-O-M) A4 OPQU Cactus Grn 2450 (\$78.00)

Global Laminates <http://www.globallaminates.com/>

machineable PCB stock

FR1 .062 1/0 40"x48"

3"x2"=16x20=320/sheet

6"x4"=8x10=80/sheet

Carbide Depot <http://www.carbidedepot.com/>

Modela Tooling

10 .010" EM SQ 4FL S/E SMG-0.03" LOC-1.5" OAL (GT 13550) \$14.29 \$142.90

25 4FL SE 1/64 AITiN COATED (SGS 30191) \$15.24 \$381.00

10 4FL SE 1/32 AITiN COATED (SGS 30192) \$8.07 \$80.70

10 4FL SE 1/16 AITiN COATED (SGS 30194) \$7.33 \$73.30

10 4FL SE 3/32 AITiN COATED (SGS 30196) \$7.06 \$70.60

10 4FL SE 1/8 AITiN COATED (SGS 30198) \$6.54 \$65.40

10 4FL SE BALLNOSE 1/64 AITiN COATED (SGS 30031) \$19.69 \$196.90

10 4FL SE BALLNOSE 1/32 AITiN COATED (SGS 30032) \$10.26 \$102.60

10 4FL SE BALLNOSE 1/16 AITiN COATED (SGS 30034) \$9.25 \$92.50

10 4FL SE BALLNOSE 3/32 AITiN COATED (SGS 30036) \$9.25 \$92.50

10 4FL SE BALLNOSE 1/8 AITiN COATED (SGS 30038) \$8.28 \$80.28

MSC <http://www.mscdirect.com>

Shopbot Tooling

62282579 2 \$20.43 ea \$40.86 Ball - Single End Mills Size: 1/8 Shank Diameter: 1/8 Length of Cut: 3/4 Overall Length: 2-1/4 Number of Flutes: 4 Ma

62282603 2 \$36.51 ea \$73.02 Ball - Single End Mills Size: 1/4 Shank Diameter: 1/4 Length of Cut: 1-1/8 Overall Length: 3 Number of Flutes: 4 Mate

85336089 2 \$15.27 ea \$30.54 4 Flute Straight Flute Centercutting Single End Mills Type: Straight Flute Size: 1/8 Shank Diameter: 1/8 Length of Cu

74210410 2 \$24.10 ea \$48.20 Standard - Single End Mills Size: 0.250 In., 1/4, 6.35 mm Shank Diameter: 1/4, 6.35 mm Length of Cut: 1.500 In., 1-1/

74210501 2 \$36.76 ea \$73.52 Standard - Single End Mills Size: 0.500 In., 1/2, 12.70 mm Shank Diameter: 1/2, 12.70 mm Length of Cut: 0.625 In., 5/

76607662 2 \$22.38 ea \$44.76 Double Edge Downtcut Spiral Flute Cutters for Wood Size: 1/8 Flute Length: 1/2 Number of Flutes: 2 Material: Solid Car

76525062 2 \$25.28 ea \$50.56 Double Edge Downtcut Spiral Flute Cutters for Wood Size: 1/4 Flute Length: 7/8 Number of Flutes: 2 Material: Solid Car

76127372 2 \$22.38 ea \$44.76 Double Edge Upcut Spiral Flute Cutters for Wood Size: 1/8 Flute Length: 1/2 Number of Flutes: 2 Material: Solid Carbi

87430062 2 \$25.28 ea \$50.56 Double Edge Upcut Spiral Flute Cutters for Wood Size: 1/4 Flute Length: 7/8 Number of Flutes: 2 Material: Solid Carbi

74326125 2 \$46.98 ea \$93.96 Ball - Single End Mills Size: 1/2 Shank Diameter: 1/2 Length of Cut: 3 Overall Length: 5 Number of Flutes: 4 Material

79690376 1 \$23.48 ea \$23.48 Er Spring - Collets Fractional Size: 1/8 Collet Series: ER25.

VMI Sales http://www.vmisales.com/plotter_blades/

Vinyl Cutter Blades

Roland 45 Degree Plotter Blades, 5 pack \$32.50/pk \$162.50

Staples <http://www.staples.com>

Modela Stock Fixturing

25 504829/Model 137 Scotch Double Sided Permanent Tape with Dispenser, 1/2" x

450"/\$2.89 Each/\$72.25

Molding and Casting Cups

5 617688/Model RK5 Translucent Plastic Cold Cups, 5-oz, 100/Pack/\$2.99 100/
Pack/\$14.95

5 563562/TP10 Solo Plastic Party Cups, 10-oz./\$6.79 50/Pack/\$33.95

5 494051/Model TP16 Solo Plastic Party Cups, 16-oz. Clear/\$5.79 50/Pack/\$28.95

Cleaning Supplies

10 538868/Model 5320 Kimberly-Clark Utility Wipes, 9" x 10 1/2", 125/Pack/\$3.79
125/Pack/\$37.90

3 428881/Model E507008 Angle Sweep Broom/\$12.99 Each/\$38.97

3 390402/Model 700 Plastic Dust Pan/\$3.15 Each/\$9.45

Office Supplies

5 229690/13023/13403 Acme 8" Economy Shears, Bent-Handle, 3/Pack/\$7.99 3/
Pack/\$39.95

5 514742/Model 11454-CC Staples Mechanical Pencils .7mm, Black Barrel w/ Blue
Grip, Dozen/\$2.98/\$14.90

5 399782/Model L50BP3HB-K6 Pentel Super Hi-Polymer Lead Refills, 0.7mm, HB,
36 Leads/\$2.09/\$10.45

5 264291/Model ZE21BP3-K6 Pentel Clic Eraser with Grip, 3/Pack/\$3.89/\$19.45

3 163451/Model 11299 Staples Glue-Top Scratch Pads, 5" x 8", White, 12/
Pack/\$9.08/\$27.24

5 609009/Model 4184/Scotch Transparent Tape with Refillable Dispenser/\$7.79 4/
Pack/\$38.95

5 452605/Model 07364/Duck HP260 Crystal-Clear Packaging Tape w/ Dispenser,
Clear, 1.89" x 60 yds/\$7.99 Each/\$39.95

Batteries

1 607025/Model MN1604TC12 Duracell 9-Volt Alkaline Batteries, 48/

Pack/\$144.99/\$144.99

Labeler And Tape

1 615073/Model PT18R Brother PT-18R Rechargeable Label Maker/\$129.99/\$129.99

3 486803/Model TZ231 Brother 1/2" (12mm) Black on White tape/\$17.99/\$53.97

3 522946/Model TZ-221/Brother 3/8" (9mm) Black on White tape/\$16.49/\$49.47

3 486852/Model TZ241 Brother 3/4" (18mm) Black on White tape/\$20.99/\$62.97

3 392381/Model TZ211 Brother 1/4" (6mm) Black on White tape/\$13.69/\$41.07

Office Depot <http://www.officedepot.com/>

variable temperature laminator

1 535400 Wilson Jones LV250HS Laminating Machine \$124.95/ea

1 777512 Memorex Spindle CD-RW 25 ct. \$16.55

1 908996 Manual Vacuum Hold Pencil Sharpener \$11.13/ea

2 317447 HP Multi Use Paper 20 lb. 96 bright \$4.50/ream

2 142364 Sanford Super Sharpie Fine Point 6/pk \$5.74 \$11.48

2 535640 Clear Laminating Pouches, Luggage Tag w/Loop, 5 mm, 2 1/2" x 4 1/4", 25-pack \$8.95/pack \$17.90

2 535704 Clear Laminating Pouches, Letter Size, 3 mm, 9" x 11 1/2", 50-pack \$11.95/pack \$23.90

2 535616 Clear Laminating Pouches, ID Badge, 5 mm, 2 9/16" x 3 3/4", 25-pack \$7.49/pack \$14.98

10 321984 Fiskars Stainless Steel Ruler, 12"(30cm) \$3.08/ea \$30.80

10 588286 Office Depot One Subject Notebooks \$1.49/ea \$11.49

10 423608 BIC Round Stic Ballpoint Pens, Fine Point, 0.8 mm, Blue, Box Of 12 \$0.99/dozen \$9.90 Plotter Markers

PC Connection/GovConnection <http://www.pcconnection.com>

1 310393 OfficePower 1500AVR Automatic Voltage Regulator UPS \$219.95

5 377857 Protect It! Surge Protector, 7-outlets, 12ft cord \$7.95 \$39.75

3 154825 10 Ft. Universal AC Power Extension @ \$5.57 \$16.71

2 7499035/HP ProCurve Switch 1400-8G, 8-Ports/\$68.95/\$137.90

1 6135184/Linksys Wireless G Broadband Router, Linux Version/\$69.95/\$69.95

5 462901 Enhanced 350 FastCAT 5e UTP Crossover Cable, 7' Gray \$1.19 \$5.95

5 318853 1000BaseTX Cat6 UTP 500MHz Gigabit Ethernet Patch Cable, 25' Gray, \$8.07 \$40.35

5 318856 1000BaseTX Cat6 UTP 500MHz Gigabit Ethernet Patch Cable, 3' Blue, \$2.53/ea \$12.65

5 318858 1000BaseTX Cat6 UTP 500MHz Gigabit Ethernet Patch Cable, 10' Blue, \$3.48/ea \$17.40

5 417517 1000BaseTX Cat6 UTP 500MHz Gigabit Ethernet Patch Cable, 5' Blue, \$3.03/ea \$15.15

1 422654 HP OfficeJet 6210 All-In-One \$188.73

1 467301 HP JetDirect 175x \$155.22

3 383323 HP 94 Black Inkjet Print Cartridges \$16.64/ea \$49.92

3 256372 HP 95 Tri-Color Inkjet Print Cartridges \$20.15/ea \$60.45

10 5726935 USB 2.0 to DB9M Serial Dongle Converter \$13.95/ea \$139.50

1 Digital Projector

(less cable, more robust networking)

110/240V

LCD projector for teaching and conferencing

<http://pcconnection.com>

In-Focus LP70+ DLP Projector \$1,149.00

Wolcott Park <http://www.wolcott-park.com>

PDMS

5 Sylgard 184: Maker: Dow Corning 1.1 pound kit. \$29.90 \$149.50

Blick Art Materials <http://www.dickblick.com/>

5 33502-1007 RUB R MOLD/QUART \$18.89 \$94.45

West Marine <http://www.westmarine.com>

Molding, Casting, Composites

2 9860008 MAS Low Viscosity Resin, 1 Quart 2.70 lb \$29.99 \$59.98

2 9860198 Mas Medium Hardener, 1 Pint 0.60 lb \$20.99 \$41.98

1 190027 Fiberglass Cloth - Density (6 OZ), 38" x 90 3.00 lb \$39.99 \$39.99

1 9860321 Colloidal Silica, .5 Gallon 0.15 lb \$15.99 \$15.99

1 9860404 Mas Phenolic Micro Balloon Filler, 1/2 Gallon 0.10 lb \$32.99 \$32.99

1 9860438 Mas Wood Flour Filler, 1/2 Gallon 0.20 lb \$13.99 \$13.99

1 9860354 Mas Cell-O-Fill Filler, 1/2 Gallon 0.45 lb \$9.99 \$9.99

1 9860388 Mas Milled Fibers Filler, 1/2 Gallon 2.65 lb \$37.99 \$37.99

1 323659 423 Graphite Powder - 12 OZ 1.00 lb \$15.99 \$15.99

1 323634 420 Aluminum Filler - 1 LB 1.28 lb \$20.99 \$20.99

2 184788 Resin Coloring Agent - Admiral Blue 0.24 lb \$9.99 \$19.98

2 184747 Resin Coloring Agent - Red 0.38 lb \$9.99 \$19.98

2 5399977 Home Dust Mask 15 Pack 0.68 lb \$15.99 \$31.98

To Add Welding

Grainger Welding Supply <http://www.grainger.com>

3 Economy Ear Muff, Noise Reduction Rating 23 dB, Dielectric, Foam Padded Ear Cushions, Color Yellow/Black CONDOR 1VT65 1 Today \$6.62ea \$19.86

3 Endmill, High Speed Steel 3/16 Inch Ball Single End CC 3/8 Inch Shank 1/2

Inch Lock 2 Flute PUTNAM 94321 \$6.58ea \$19.74

1 Heavy Duty Multi Purpose Rubber Air Hose, Inside Diameter 1/4 Inch, OD 0.500 Inch, Fitting Size 1/4 NPT, Pressure Range 250 PSI, Color Red, Length 25 Feet, DAYTON 1Z666 \$16.19ea \$16.19

2 Welding Wire, Diameter 0.030 Inch, 2 Pounds per Spool, E71T-GS Flux Cored MIG ESAB CORESHIELD 242201838 \$17.64ea \$35.28

1 Grinding Wheel Dresser, Diameter 1 1/4 Inches, Length 8 1/2 Inches DAYTON 2X951 1 \$7.55ea \$7.55

1 Heavy Duty Multi Purpose Rubber Air Hose, Inside Diameter 1/4 Inch, OD ch, Fitting Size 1/4 Inch MNPT, Pressure Range 250 PSI, Color Red, Length DAYTON 2Z010 \$25.20ea \$25.20

1 Crimped Wheel Brush, Diameter 6 Inches, Wire Size 0.0118 Inch, Maximum Speed 6000 RPM, Arbor Hole 5/8-1/2 Inch, Face Width 3/4 Inch, Narrow Brush Face, WEILER 01065 \$13.22ea \$13.22

1 Variable Speed Rotary Tool, 5,000 To 35,000 RPM, 1.15 Amps @ 120 Volts, Tool Weight 1 Pound, Tool Length 8 Inches Long, Includes 77 Accessories, Garden DREMEL 3956-02 \$79.00ea \$79.00

1 Router, Power Rating 1 3/4 HP, Current @ 120 VAC 10 Amps, No Load Speed 23000 RPM, Power Source AC, Switch Rocker, Tool Length 8 Inches, Tool Weight 8 PORTER CABLE 690LR \$164.48ea \$164.48

1 High Speed Steel Router Bit Set, Number of Pieces 6, Includes 1/4, 3/8 and 1/2 Inch Straight Bits, 1/4 Inch Veining, 3/8 Inch Corner Rounding and 3/8 Inch MAGNA 83101 \$25.79ea \$25.79

3 Mig/Tig Welding Glove, Size Large, Grain Pigskin, 4 In Split Leather Cuff, Pair CONDOR 4JF94 \$7.14ea \$21.42

3 Mig/Tig Welding Glove, Size Medium, Grain Pigskin, 4 In Split Leather Cuff,

Pair CONDOR 4JF95 \$7.14ea \$21.42

1 Fold-Up Hex Key Set Combo Pack, Number of Pieces 5, Sizes Included 1.5,2.0,2.5,3.0,4.0,5.0,6.0,8.0,10.0 Metric, T8, T10, T15, T20, T25, T27, T30,T40 Torx, 0.050, 1/16, 5/64, 3/32, 7/64, 1/8, 9/64, 5/32, 3/16, 7/32, 1/4,5/16,3/8 EKLIND 25036 \$29.43ea \$29.43

3 Super Slim Super Tuff Welding Helmet, Plate Size 2 x 4 1/4 Inches, Lift Front Plate Retainer, Ratchet Headgear, Thermo Plastic Resin SELLSTROM 29301-10 \$32.67ea \$98.01

1 Wire Feed MIG Welder, Rated Output 90A @19VDC, Input 115 V, Input 20 Amps, Phase 1, OCV 29, 60 Hz, Shielding Gas Ar2, C25, Wire Size 0.023/0.025/0.030/0.035, HOBART CORPORATION 500487 \$362.70

3 Pneumatic Coupler Body, Type Sleeve, Quick Coupler, Body Size 1/4 Inch, Connection Size 3/8 Inch FNPT, Used on End of Hose or Pipe, Zinc Plated Steel, DYNAQUIP D360 \$4.90ea \$14.70

3 Pneumatic Coupler Plug, Body Size 1/4 Inch, Connection Size 3/8 Inch FNPT, Steel DYNAQUIP P360 \$2.68ea \$8.04

1 SAE/Metric Box End Wrench Set, 14 Pieces, Includes Size 1/4 x 5/16, 3/8 x 7/16, 7/16 x 1/2, 1/2 x 9/16, 9/16 x 5/8, 11/16 x 13/16, 3/4 x 7/8 Inch, 6 x WESTWARD 4YR23 \$48.98ea \$48.98

1 Locking Pliers Set, 3 Pieces, 5 and 10 Inch Curved Jaw, 6 1/2 Inch Long Nose WESTWARD 4YR96 \$22.25ea \$22.25

1 Heavy Duty Bench Grinder, Wheel Diameter 6 Inches, Power Rating 1/3 HP, Maximum Speed 3450 RPM, Arbor Wheel 1/2 Inch, Current Rating 3.5 Amps, Single Phase DAYTON 4Z672E \$119.93ea \$119.93

6 Light Duty Bar Clamp, Load Capacity 600 Pounds, Opening 12 Inches, Throat

Depth 2 1/2 Inches, Bar Thickness 1/4 Inch, Swivel Pad 3/4 Inch, Width 3/4 Inch, WILTON 42912 \$5.66ea \$33.96

1 Welding/Chip Hammer, Handle Type Steel with Vinyl Grip, Head Weight 14 lb, ESTWING E3-WC \$18.32ea \$18.32

1 Ball End Hex Screwdriver Set, 13 Pieces, Blade Length 4 to 6 Inches, Included Sizes: 0.050, 1/16, 5/64, 3/32, 7/64, 1/8, 9/64, 5/32, 3/16, 7/32, 1/4, 5/16, 3/8 EKLIND 90113 \$32.94ea \$32.94

1 Ergo File Set, Number of Pieces 5, Type General Purpose, With Pouch, N 22040H \$39.56ea \$39.56

3 Bib Apron, Size 24 x 36 Inches, Protective Leather, Thread, Premium Cowhide, CONDOR 5T179A \$19.63ea \$58.89

1 Disposable Ear Plug, Without Cord, NRR 28 dB, Material Foam, Bell Shaped

To Add Plasma Cutting:

Thermal Dynamics Cutmaster 101 Plasma Cutter w/Machine Torch and Torchmate AVC Modification \$2,685.00 Arc Voltage Torch Height Control \$2,399.95

*Be sure to specify Voltage, Hz and Amps required (e.g. 220V, 50Hz, 15 Amps)
<http://fab.cba.mit.edu/about/fab/inv.html>

Web Links

MIT

http://www.ted.com/index.php/talks/neil_gershenfeld_on_fab_labs.html

<http://fab.cba.mit.edu/>

<http://ng.cba.mit.edu/dist/fab.pdf>

<http://fab.cba.mit.edu/about/fab/inv.html>

<http://fab.cba.mit.edu/about/fab/>

White Paper

<http://www.principalvoices.com/2007/technology.innovation/white.papers/neil.gershenfeld.html>

(copy at <http://ng.cba.mit.edu/dist/PV.pdf>)

USFLN

<http://www.usfln.org/>

MDFP

<http://www.usfln.org/>

Websites

www.furdyk.com

<http://www.tigweb.org/>

<http://www.npr.org/templates/story/story.php?storyId=5008294>

http://www.aidg.org/component/option,com_jd-wp/Itemid,34/p,1369/

<http://www.tech-center-enlightentcity.tv/>

Presentations

http://www.ted.com/tedtalks/tedtalksplayer.cfm?key=n_gershenfeld

Interview

http://www.sciencefriday.com/pages/2005/Nov/hour1_111105.html

Articles

http://www.usatoday.com/tech/news/techinnovations/2005-11-06-fab-lab_x.htm

http://www.businessweek.com/magazine/content/05_18/b3931027_mz005.htm

Events

<http://cba.mit.edu/events/07.08.fab/>

Fab Lab Charter

<http://fab.cba.mit.edu/about/charter/>

Video Conferencing

<http://fab.cba.mit.edu/content/processes/video>

Video Clips

<http://www.principalvoices.com/2007/technology.innovation/video/neil.gershenfeld/>
(copy at <http://ng.cba.mit.edu/dist/PV.mp4>)

Reference Books

Purchase through Amazon.com

"Programming and Customizing the AVR Microcomputer", Dhananjay Gadre
ISBN:007134666X

"Practical Electronics for Inventors", Paul Scherz ISBN:0070580782

"Electric Motors and Their Controls: An Introduction", Tak Kenjo ISBN:0198562403

"Electric Motors and Control Techniques", Irving M. Gottlieb ISBN:0070240124

"Knoppix Hacks", Kyle Rankin ISBN:0596007876

"Analog Interfacing to Embedded Microprocessor Systems", Stuart Ball
ISBN:0750677236

"Linux Cookbook", Carla Schroder ISBN:0596006403

"AVR: An Introductory Course", John Morton ISBN:0750656352

"Handbook of Modern Sensors: Physics, Designs and Applications", Jacob Fraden
ISBN:0387007504

"Precision Machine Design", Alexander Slocum ISBN:0872634922

"The Art of Electronics", Paul Horowitz, Winfield Hill ISBN:0521370957

"Learning Python, Second Edition", Mark Lutz, David Ascher ISBN:0596002815

"Python in a Nutshell", Alex Martelli ISBN:0596001886

"The Official Blender 2.3 Guide: Free 3D Creation Guide for Modeling, Animation and

Rendering", Ton Roosendahl, Stefano Selleri ISBN:1593270410

"Building Scientific Apparatus", John Moore, et al. ISBN:0813340063

"The Electronics Handbook", Jerry C. Whittaker ISBN:0849383455

"Linux for Dummies" ISBN:0764579371